Q III® Surface Particle Detector

User Group Presentations

San Francisco

July 18, 1996

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contamination control systems

August 26, 1996

TO: Industry Professionals concerned with Contamination Control

On July 18, 1996, Dryden Engineering Company, Inc. hosted a User Group Meeting in San Francisco for contamination-control personnel who have had experience with the QIII® Surface Particle Detector. The meeting was held in conjunction with SEMICON West.

This booklet contains copies of the visual materials that were used by the seven contamination-control experts who delivered presentations at the meeting, detailing the experiences with and applications for the QIII Surface Particle Detector. Application viewpoints included: semiconductor fabrication; process equipment manufacturing; testing laboratories; laser optics processing; component suppliers, and cleanroom disposables.

As President of Dryden Engineering, I personally would like to publicly state our appreciation to chairman Dan Doran of Symbios Logic and to the presenters identified in the proceedings contained in this booklet. Their generous contribution of time and shared-experience typifies the cooperative effort that continues to move our industry forward in the face of accelerating contamination-control challenges.

Dryden Engineering is encouraged by the significant success already reported for diverse applications of the QIII Surface Particle Detector, and we have committed the requisite R&D funding for future product iterations that will address additional needs that surfaced during the User Group Meeting.

Gene J. Sullivan
President

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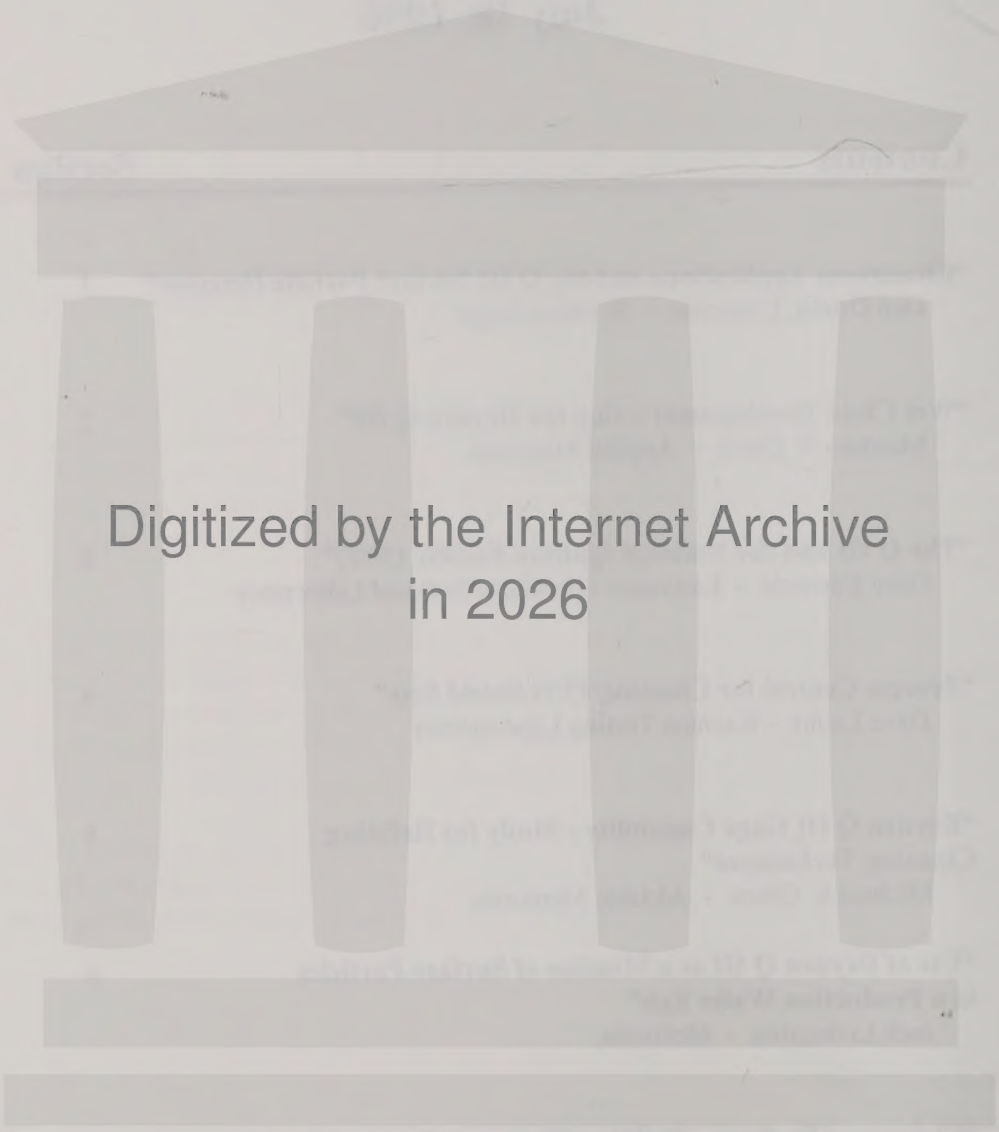
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DRYDEN

Dan Doran

Dan Doran is the Defect Reduction group leader at Symbios Logic, Fort Collins, Colorado an ASIC manufacturing facility.

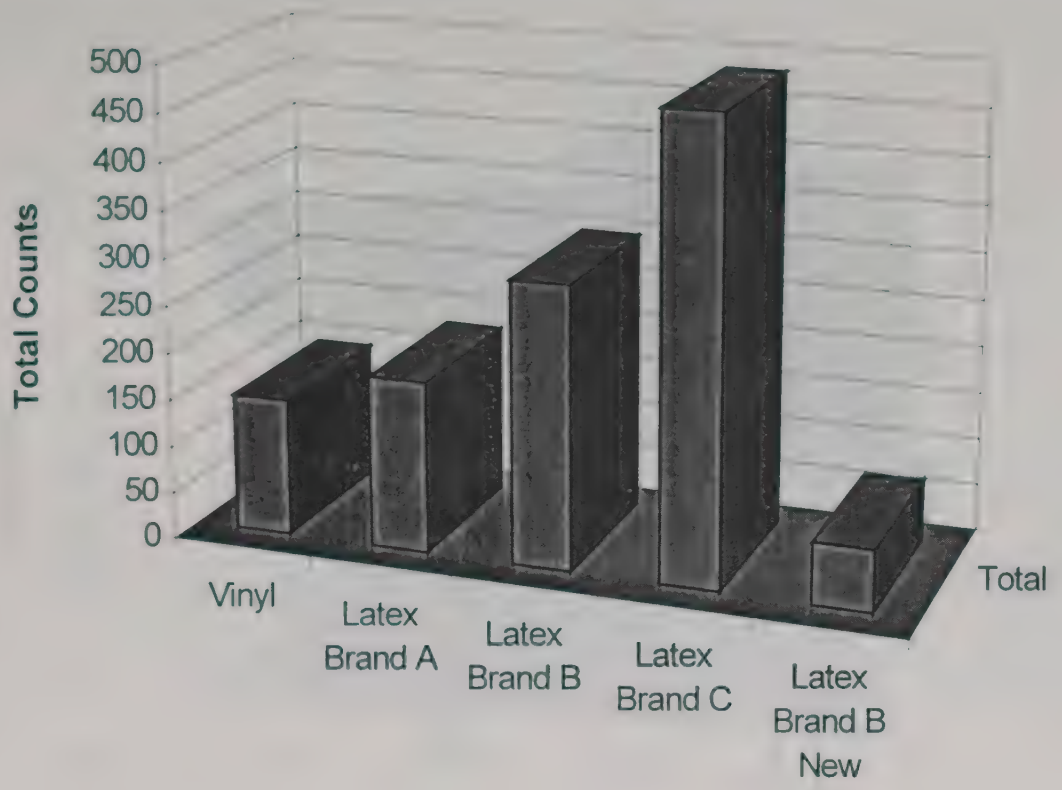
Dan has held positions in both manufacturing and process engineering since 1980.

Over the past sixteen (16) years Dan has been involved in SMIF implementation, defect reduction, 6-inch wafer fab conversions and implementation of 1 micron process technology.

Dan is presently working on submicron conversion of the Fort Collins facility.

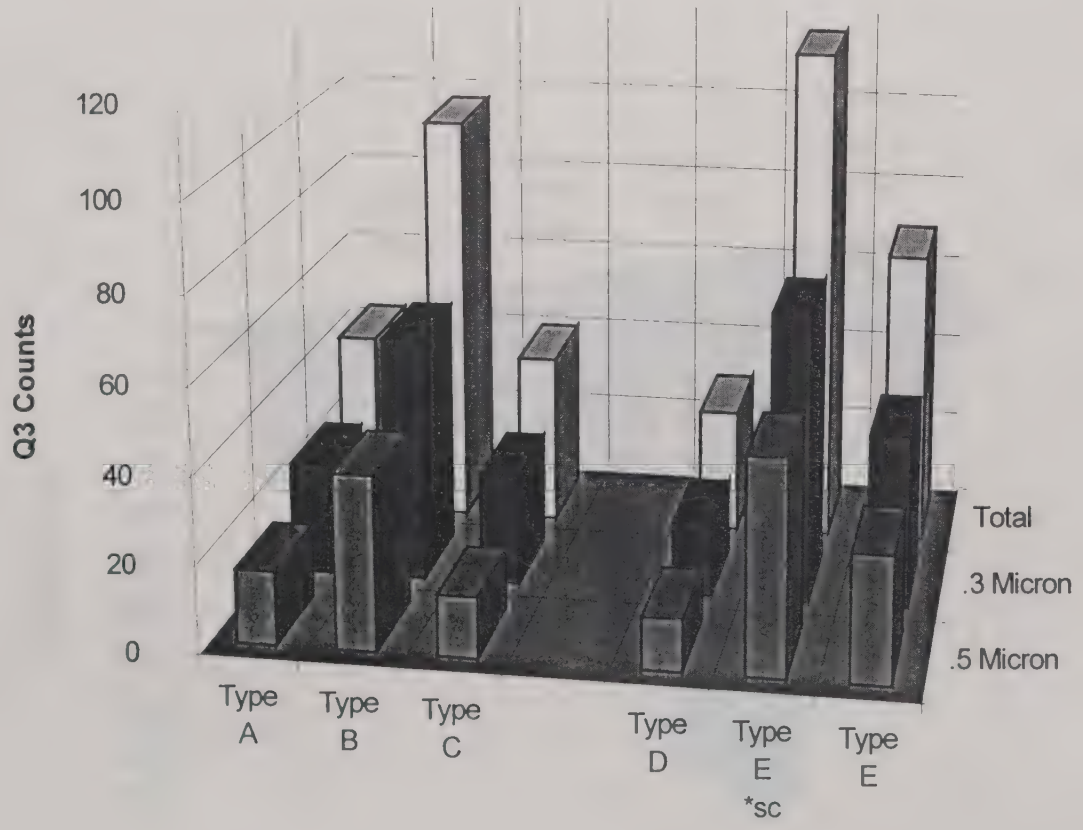
Dan has four children and enjoys cycling, mountain biking and skiing.

Glove Tests - Surface Particle Counts



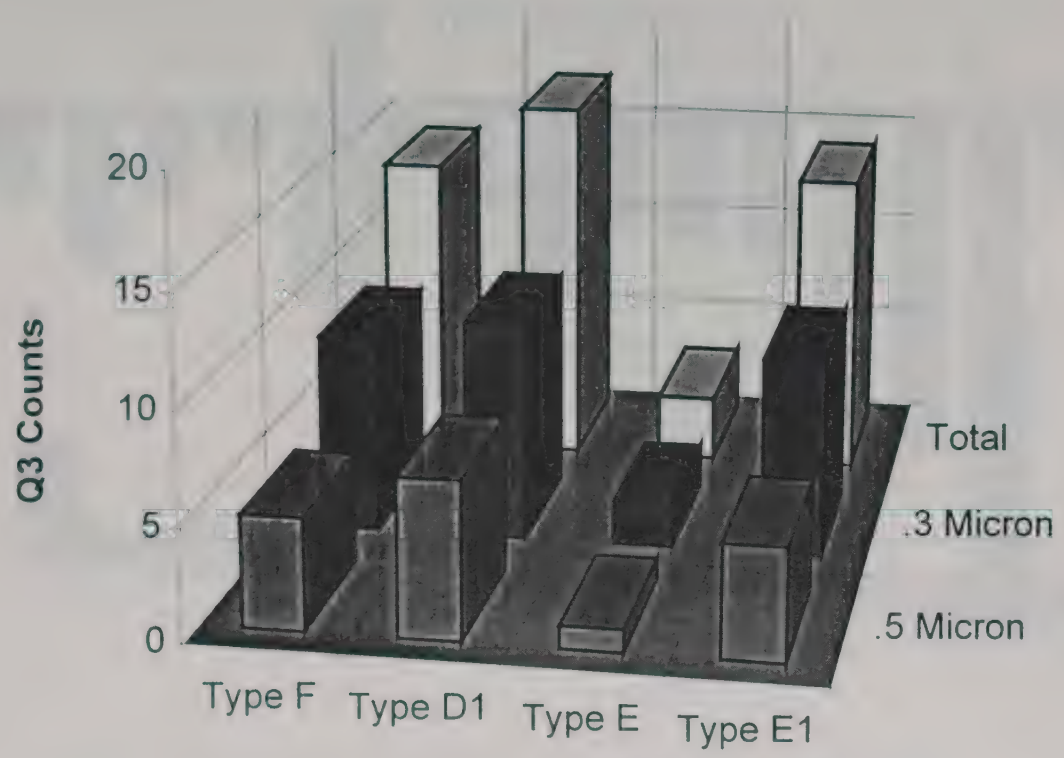
SYMBIOS LOGIC

Old vs. New Cassettes - Surface Particle Counts



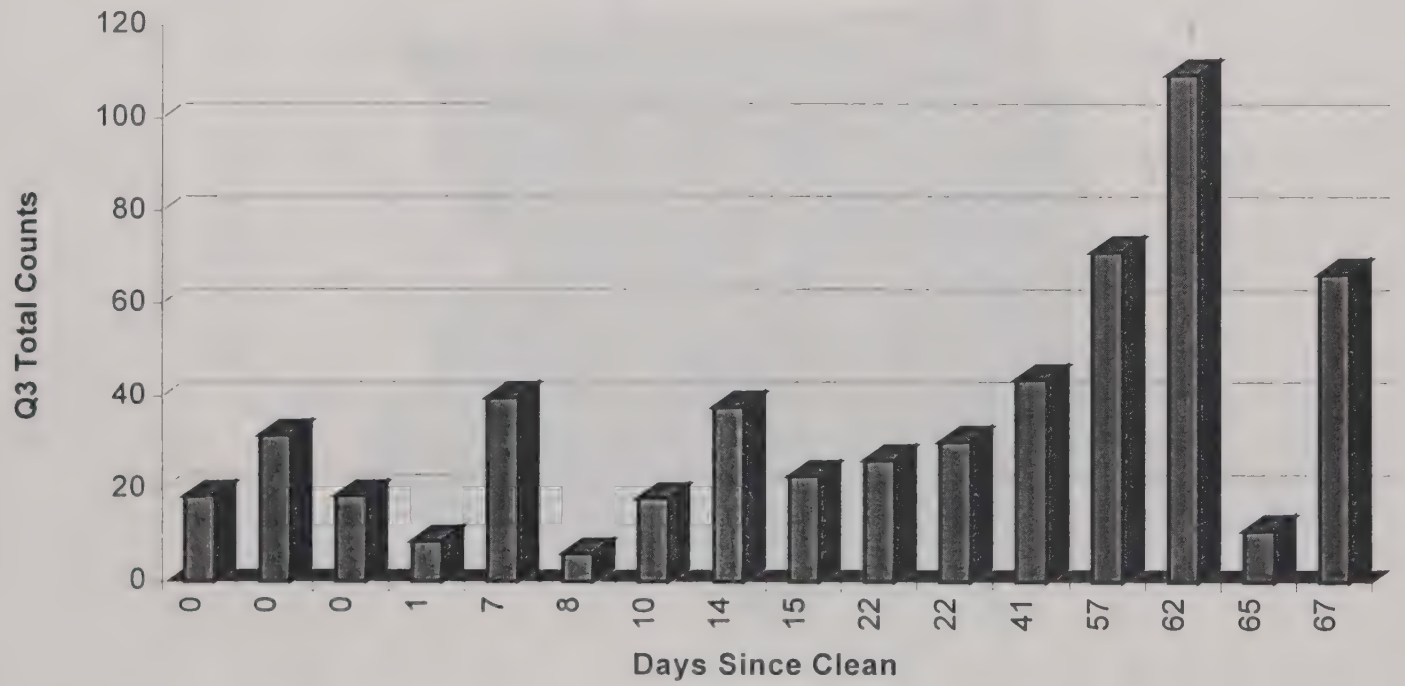
SYMBIOS LOGIC

New Cassettes - Re Cleaned



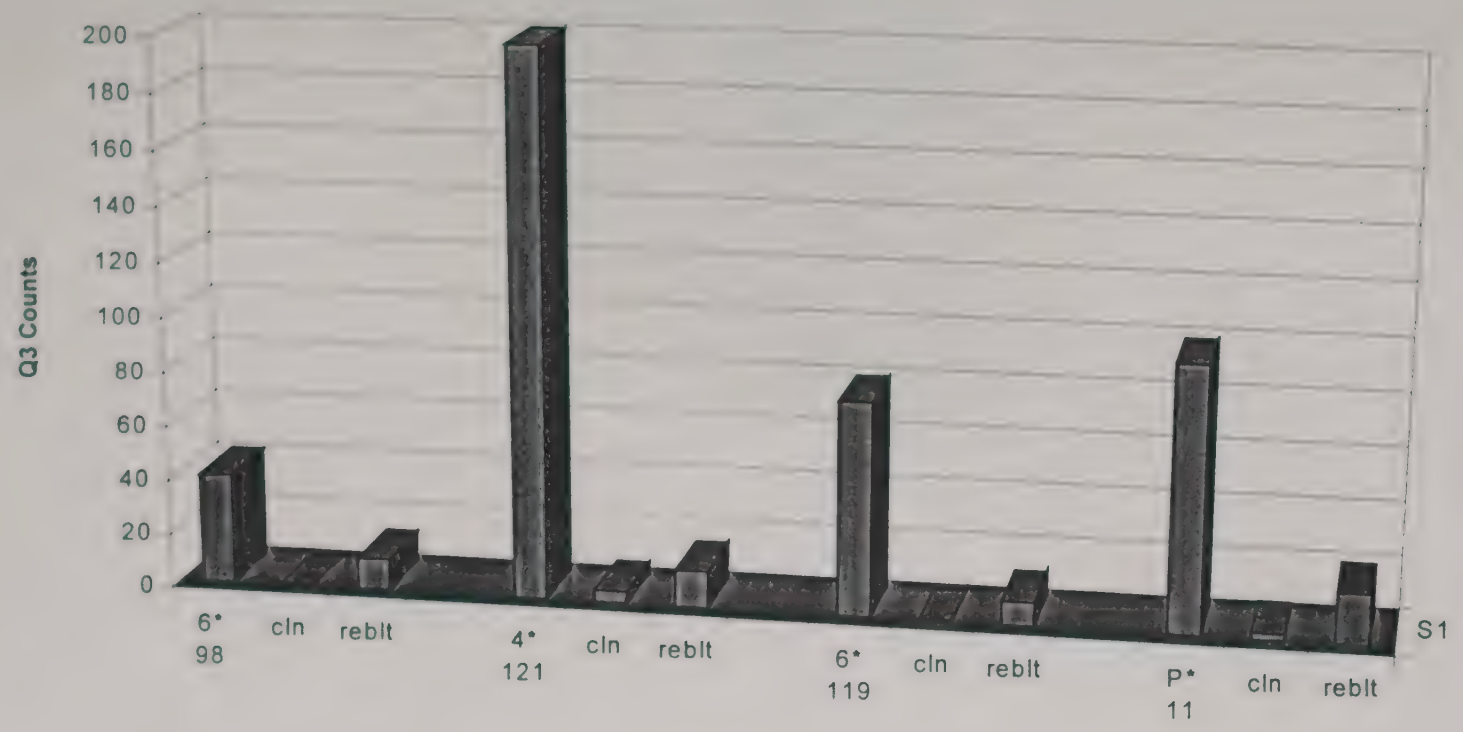
SYMBIOS LOGIC

SMIF Pod Surface Particle Counts (per in2 >.3u)



SYMBIOS LOGIC

SMIF Pod Maintenance Cycle



SYMBIOS LOGIC

Matthew F. Davis

Matthew earned a MSEE with a specialization in Ceramic superconductor Materials Science form the University of Houston in 1989.

He has worked for six (6) years as a researcher and research engineer for the Texas Center for Superconductivity at the University of Houston, specializing in the design, realization and operation of laser ablation equipment for growing large epitaxial ceramic superconductor films.

In 1985, Matthew became a process engineer for Applied Materials responsible for conceiving and implementing solutions to difficult process and microcontamination problems at customer installations.

His interests range from sailing and motorcycling to mead making.

Wet clean development using the Dryden QIII

Matthew Davis
Applied Materials
Conductor Etch Product Support

Outline

- Wet cleaning essentials
- QIII utilization
- Application of QIII to AMAT hardware
- Wet clean test findings

Wet cleaning essentials

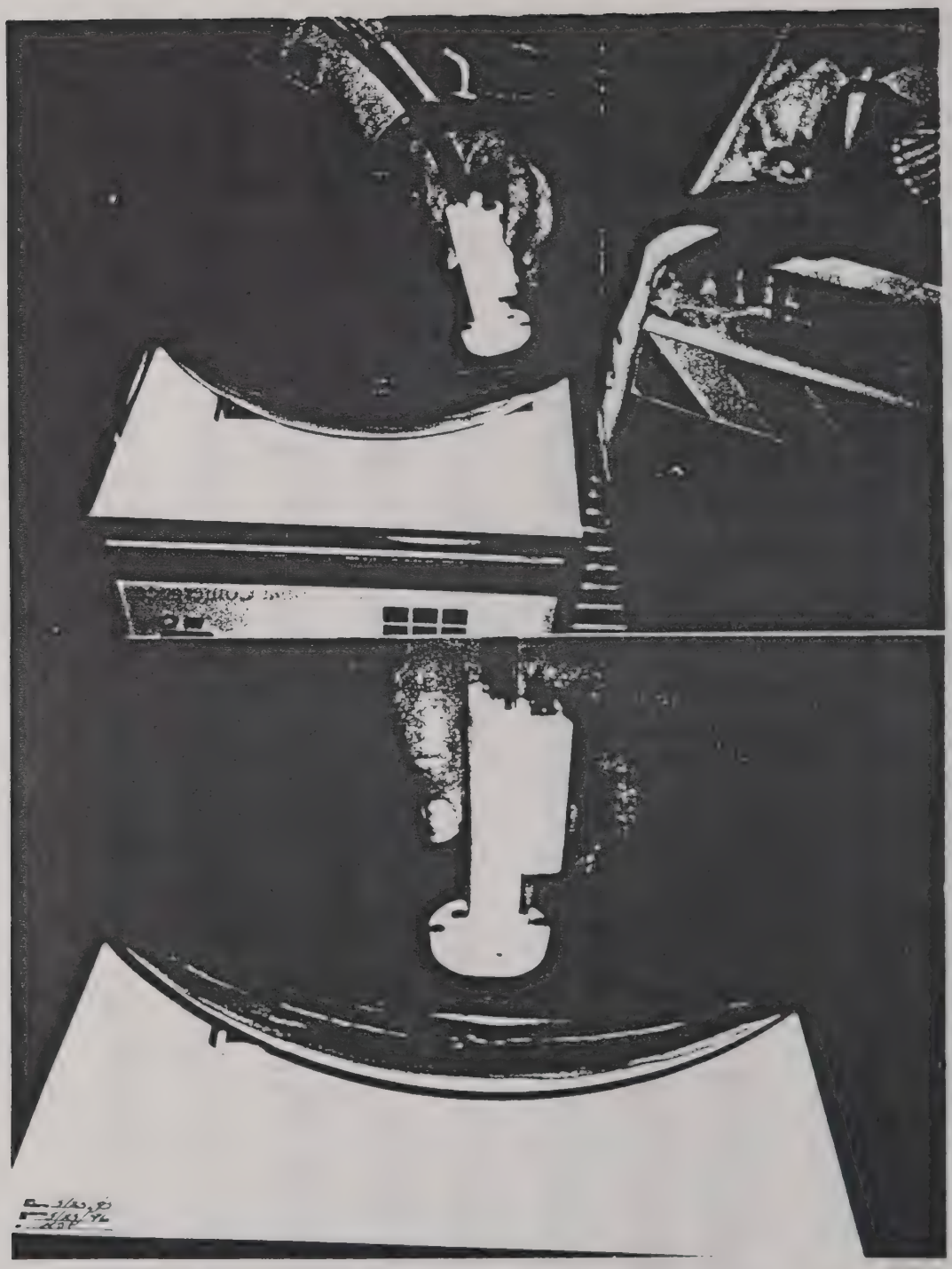
- etch deposits are removed by physical cleaning before building up to thicknesses which shed particulates.
- Wet cleaning usually employs abrasive (Scotch Brite) breakup of deposits. The resulting particles are removed by damp wiping.

QIII utilization

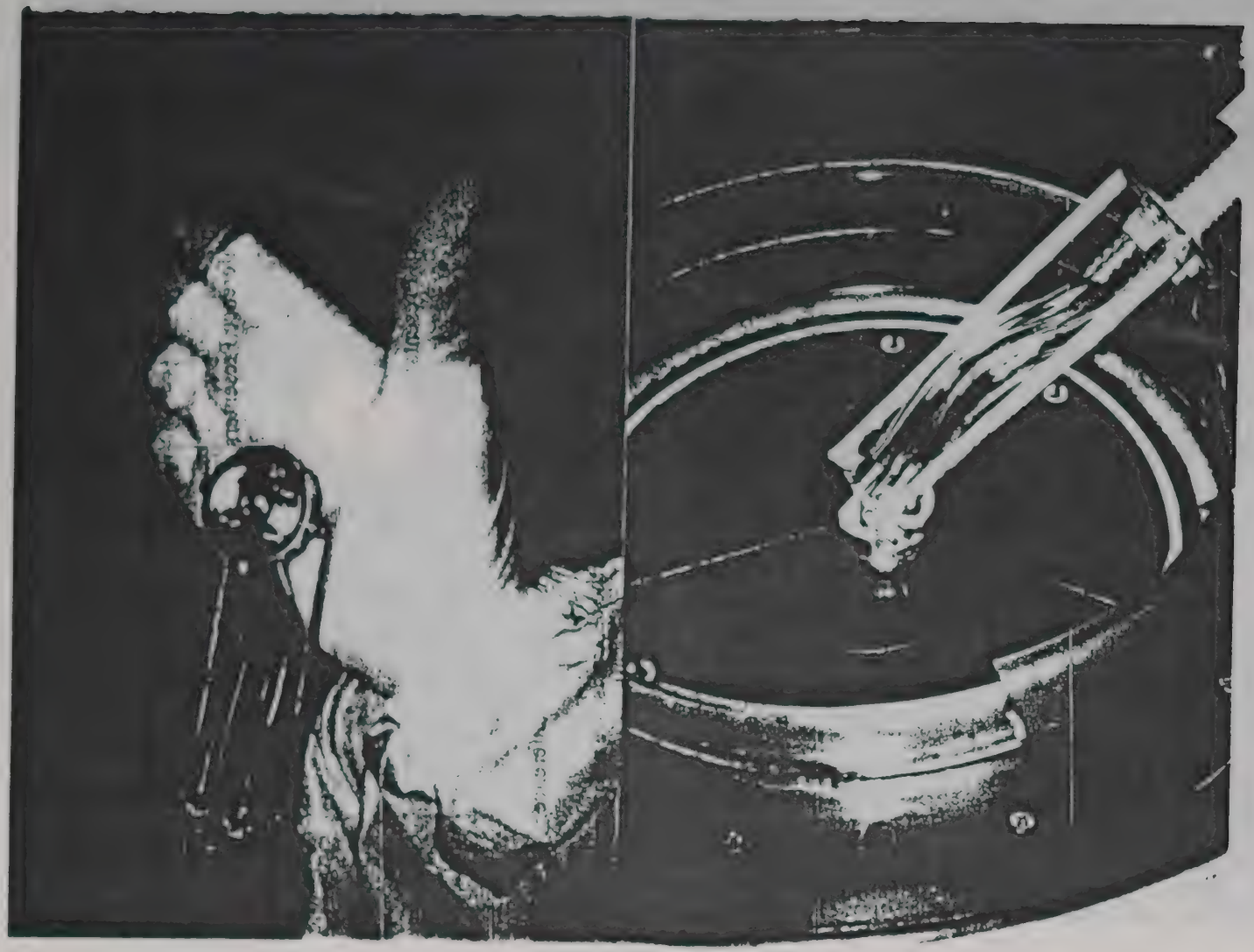
- The total system downtime is dominated by pumping time. It is thus important to verify cleanliness prior to pumpdown.
- Established wet cleaning practice differs considerably from customer to customer. When troubleshooting particulate problems, it is important to verify that these specific cleaning practices are effective.

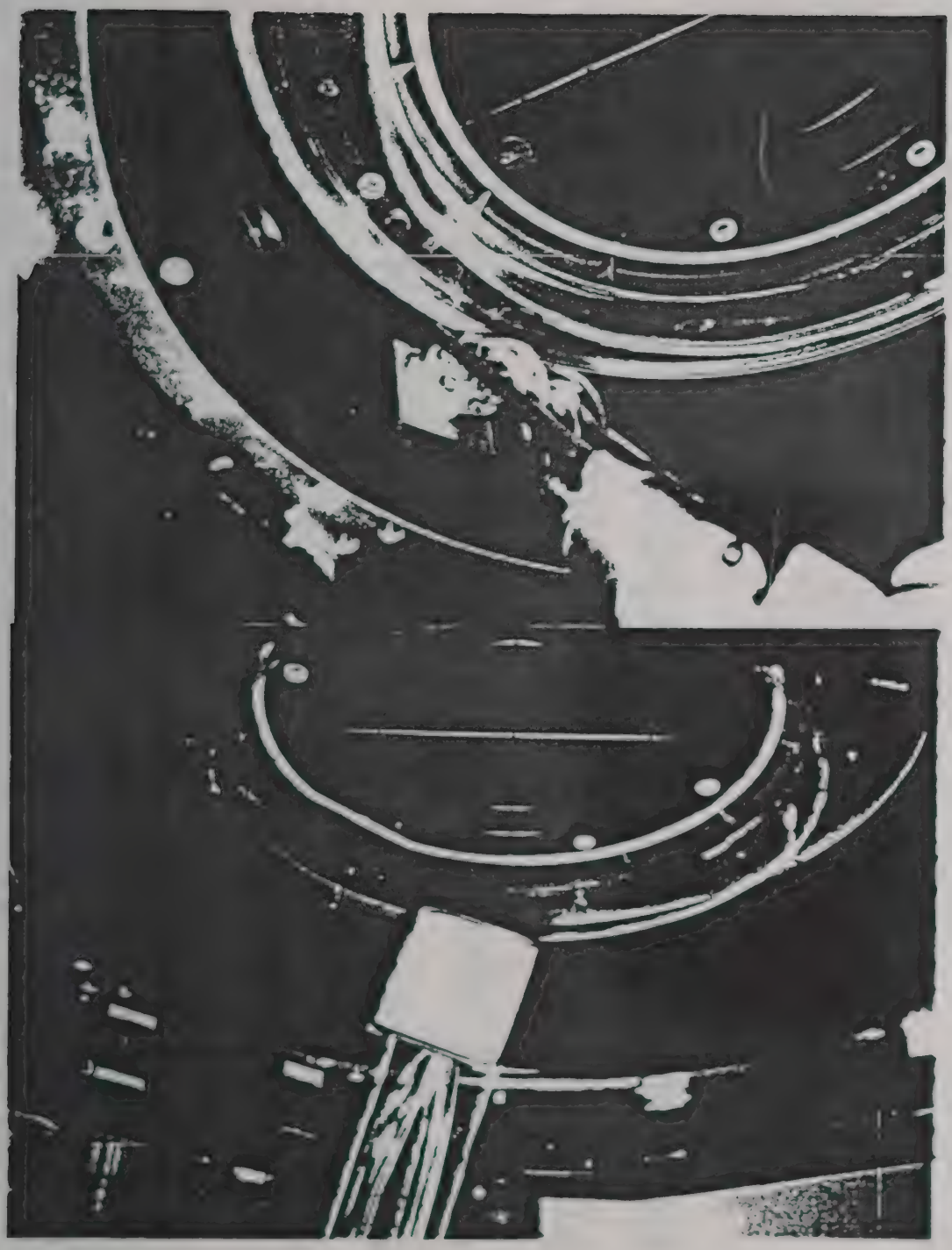
application of QIII to AMAT hardware

- Standard probe is not optimized for use on the particular curvatures and in narrow passages of a standard etch chamber.
- AMAT-designed probe heads access most surfaces. One type of head is for checking disassembled parts, the other is for surveying an assembled chamber prior to pumpdown (reaches into small openings).



Probe head use





Wet clean test findings

- Etch deposits must first be broken up with abrasives such as Scotch-Brite.
- At least two separate final wipes (each with a fresh cleanroom wipe) must be used to achieve a clean surface.

APPLIED MATERIALS - Silicon Etch Product Group

Technical Update

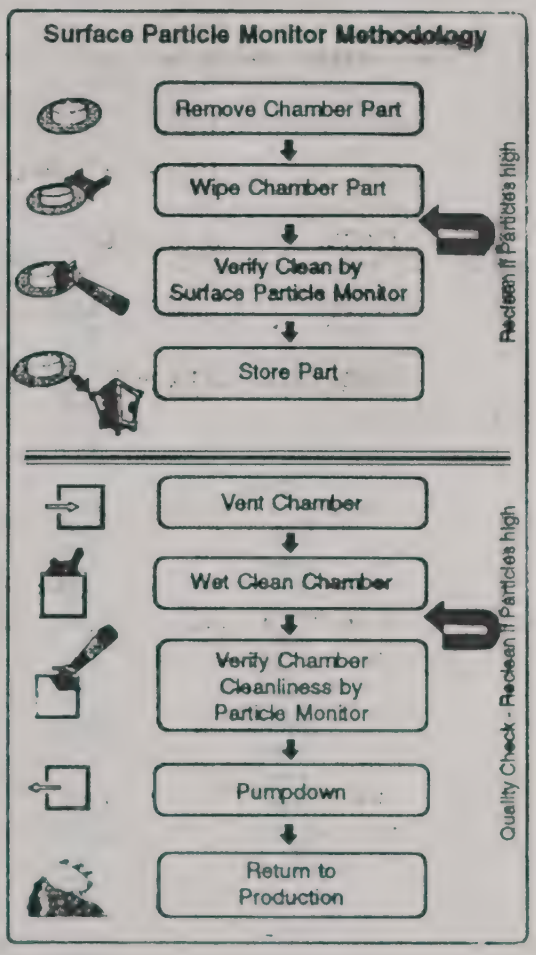
August 1, 1995

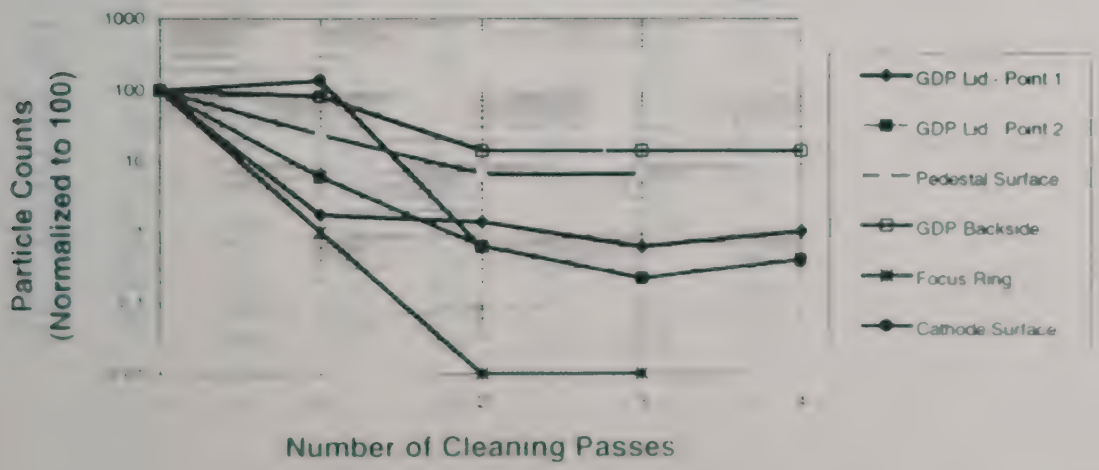
A Chamber Cleaning Particle Monitor

Through the use of a Surface Particle Monitor and a specially developed probe for 5000 etch chambers, the effectiveness of the wet chamber cleaning procedure can be monitored. Recovery times from scheduled maintenance can be reduced by increasing the confidence in particle recovery. This monitoring technique can also assist in the training of maintenance personnel on developing an adequate procedure and eliminate the high degree of variability between personnel. The Surface Particle Monitor is also useful in monitoring the condition and cleanliness of previously used chamber parts and to ensure that a thorough and optimal wet clean has been performed.

The surface particle monitor used in these studies was the QIII® from Dryden Engineering. This unit uses a portable scanner that lightly passes over a test surface. Particles on the surface are fluidized by the high pressure air discharged through the openings in the scanner head, and are then pulled through the scanner to the monitor. Particles are detected and sized by a solid state laser diode light source and collection optics. Light bursts on a photodiode are converted to electrical pulses with the pulse height proportional to the particle size. These results can be expressed in particles per square inch or square centimeters in two size bins from 0.3µm to 10µm

By monitoring the detected surface particle counts from a component, which could be a focus ring, gas distribution plate or the chamber walls, a qualitative determination on the cleanliness can be obtained. Field data in Fig.1 shows that at least two cleans* were required to minimize particulate contamination with many chamber components. Particle counts continued to drop after successive cleaning* (wiping) and stabilized readings were not obtained until after 2 passes





Summary

- QIII use can help eliminate excess production downtime from a poorly executed wet clean.
- General wet clean procedures can be developed and optimized with QIII.
- Best QIII usage is made with probe heads which are specially constructed for the surfaces of process chambers.

Gary Edwards

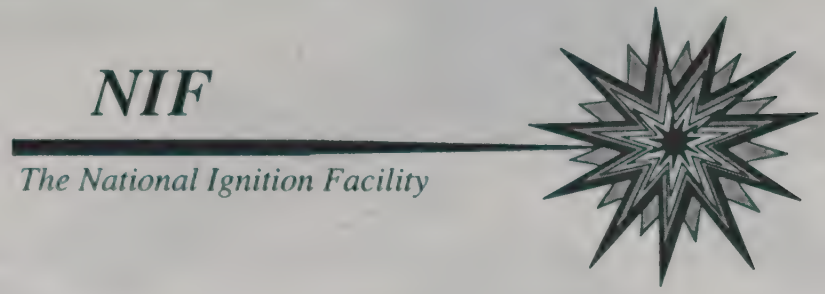
Gary Edwards is the National Ignition Facility (NIF) Optics Processing group leader responsible for the development and implementation of the metrology; quality control; cleanliness control; optics component cleaning and coating and packaging and handling of all optics for the NIF.

Gary has been employed at Lawrence Livermore National Laboratory (LLNL) fourteen (14) years in which time he has been involved in contamination control and optics processing in the construction and operation of Nova, the world's largest fusion research laser system and Beamlet, a single beamline prototype for the NIF.

Gary earned a BS degree in Administration from Upper Iowa University in 1978.

Gary was previously employed in Civil Service for nine (9) years with the U.S. Air Force Rescue and the Federal Aviation Administration as an Air Traffic Controller.

The QIII and the National Ignition Facility (NIF)



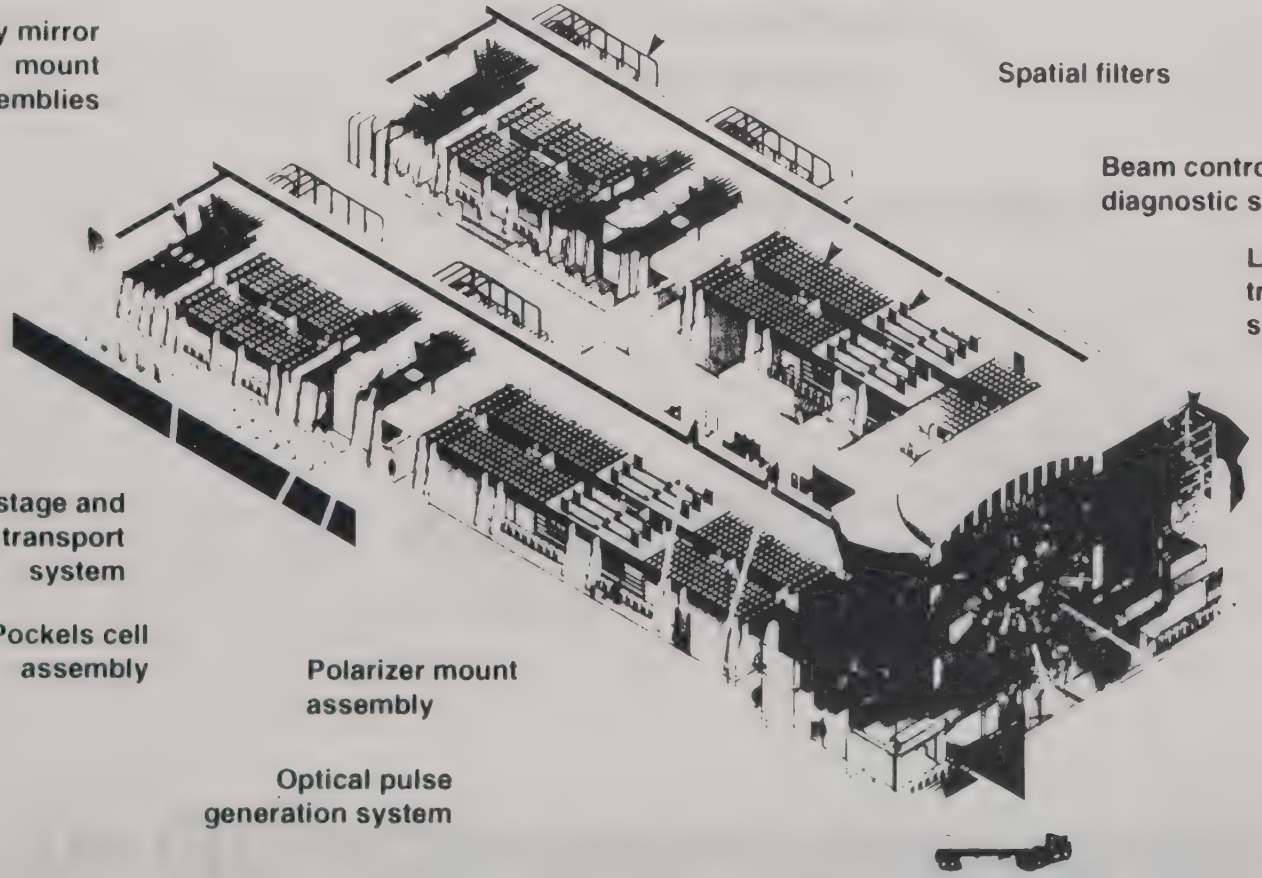
Gary Edwards
NIF Optics Processing Group Leader

Dwight Heggins
NIF Optics Processing QC

Ray Brusasco
NIF Cleanliness Control Manager

National Ignition Facility has 192 beams of 40-cm aperture arranged in four beam clusters

NIF
The National Ignition Facility



The National Ignition Facility

NIF
The National Ignition Facility

- Proposed U.S. Department of Energy national center to study inertial fusion and high-energy-density science.

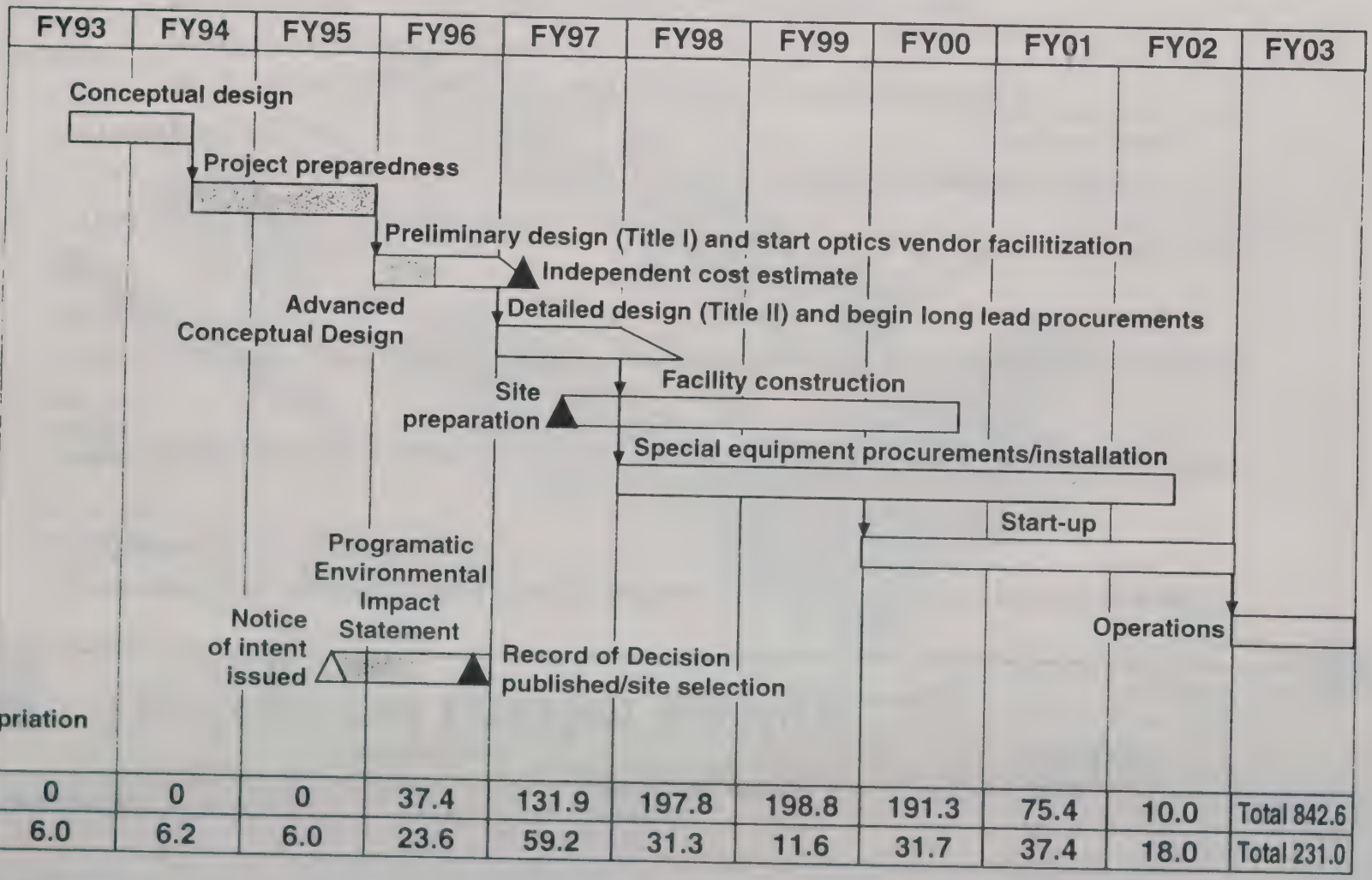
- NIF will be utilized by scientists from a host of different institutions and disciplines.

- The 192 beams of the NIF will "ignite" small fusion targets, creating energy gain in a fusion reaction.

- This highly technical facility will:
  - Provide a national research facility for Inertial Confinement Fusion ICF) studies
  - Help assure the reliability, safety and effectiveness of the U.S. nuclear weapons deterrent
  - Develop ICF as a future source of clean, plentiful energy
  - Advance basic science and technology
  - Enhance the competitiveness of key American industries

FY96 activities culminate in three major critical-path milestones that launch the construction project

NIF
The National Ignition Facility



Appropriation ($M)										
TEC	0	0	0	37.4	131.9	197.8	198.8	191.3	75.4	10.0	Total 842.6
OPC	6.0	6.2	6.0	23.6	59.2	31.3	11.6	31.7	37.4	18.0	Total 231.0

U.S. Department of Energy
Energy Systems Acquisition Advisory Board

NIF
The National Ignition Facility

NIF Project will utilize a broad U.S. manufacturing base

	Type of business	Number
★	Small business	203
☆	Woman-owned small business	23
★	Small disadvantaged business	23
☆	Large business	62

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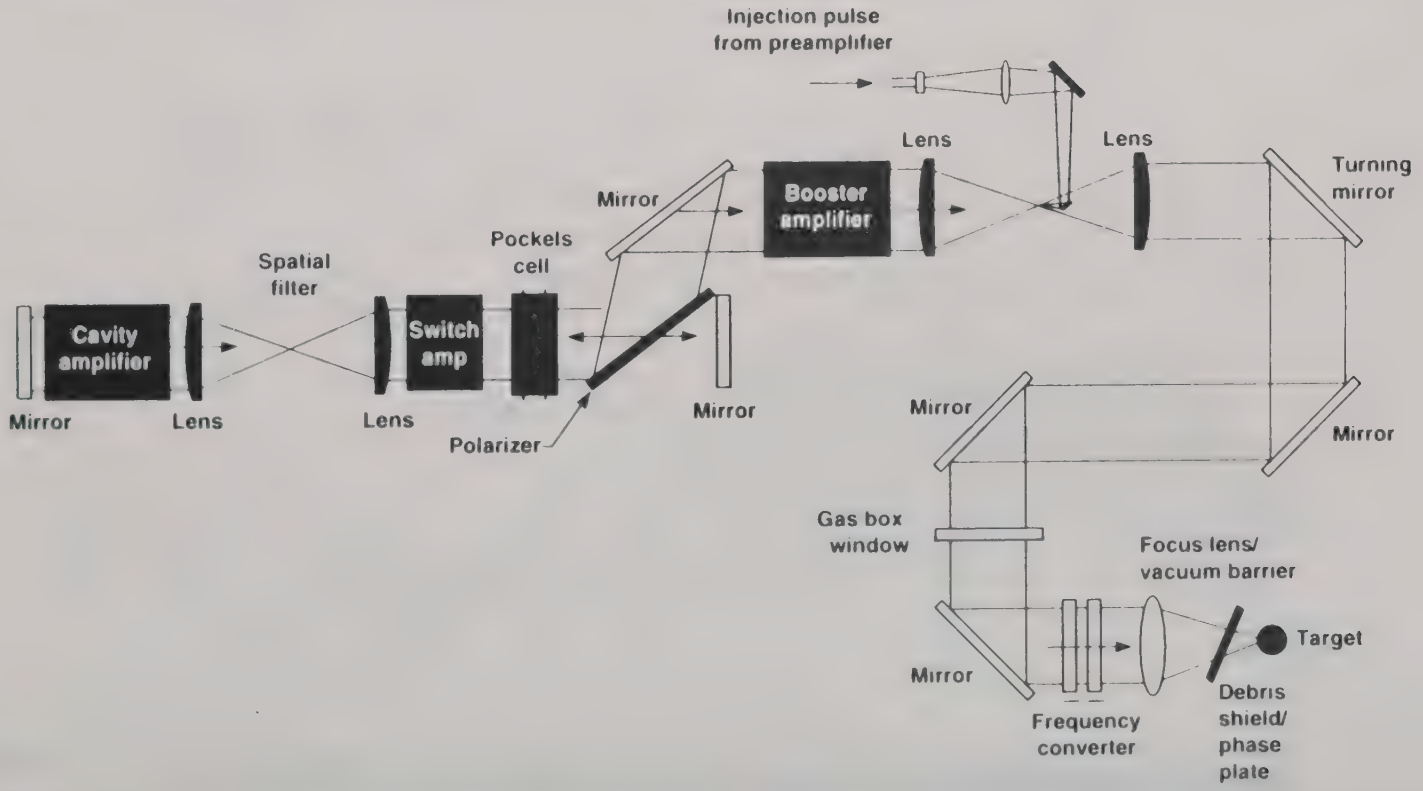
The NIF four-pass laser architecture contains 39 large-aperture optical components per beam-line

NIF

The National Ignition Facility



Mission Statement: LLNL Optics processing Group

NIF
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The primary mission of the NIF Optics Processing Group is to supply high quality optic assemblies to the NIF laser system and recommend procedures and equipment to maintain quality after installation. This includes receiving optical components at the NIF storage facility, optics storage and inventory (material process control), transportation, precision mechanical and optical cleaning, optical sol gel coatings, optical measurements and inspections, assembly, quality control, and cleanliness control. This mission will be accomplished by:

- Implementation of processes, procedures, and design monitoring that will insure high quality, clean optical assemblies before and after installation on the NIF laser system.

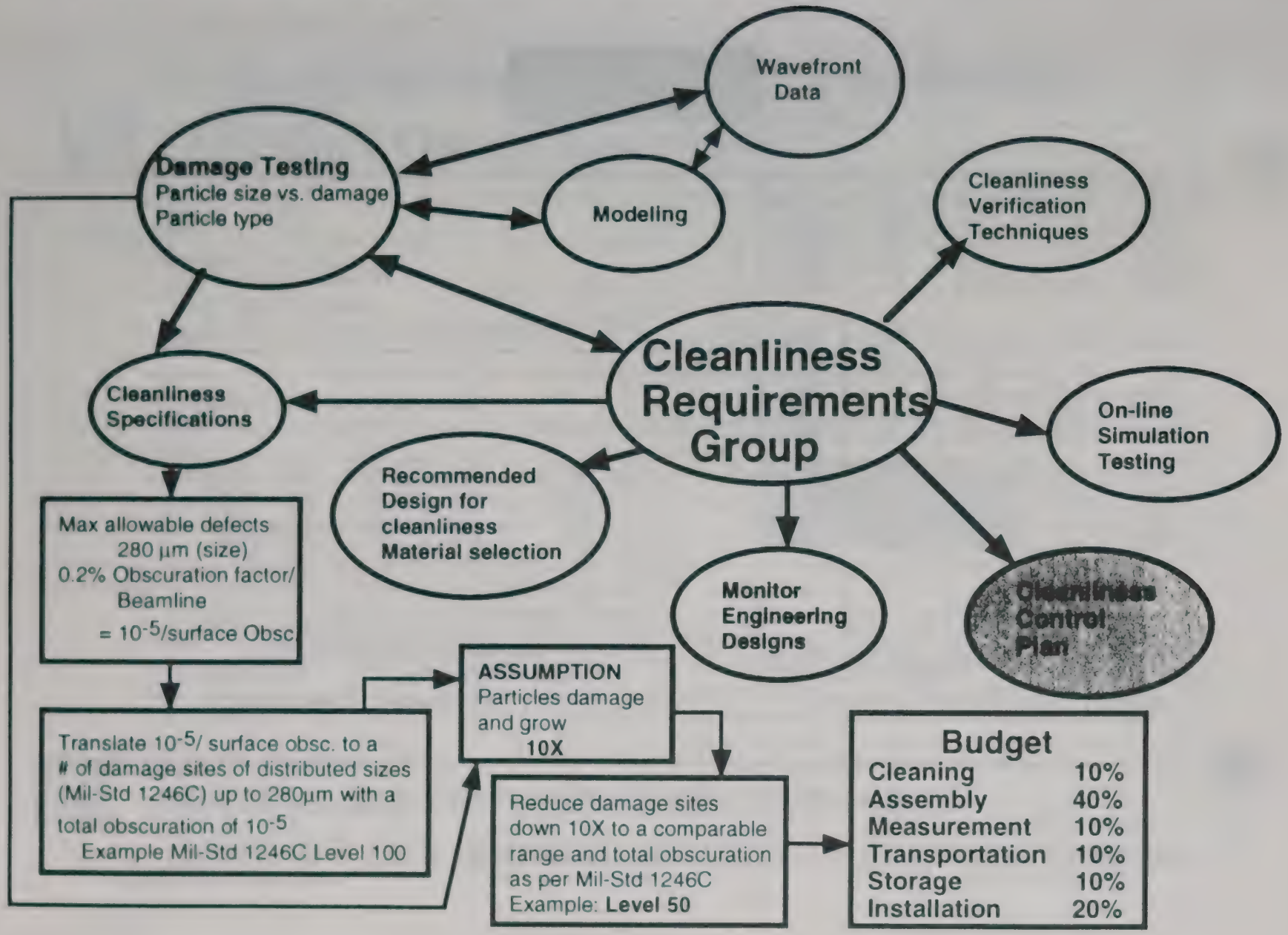
- Specification and procurement of process tools and equipment for installation into the Optics Processing Facilities and the Optics Assembly Building.

- Implementation of a work environment that will allow team members to maximize their contributions to organizational goals and individual goals.

The NIF Optics Facilities will process mechanical and optic components

- Over 7500 large aperture (40cm) optics including amplifier slabs, lenses, mirrors, polarizers, KDP crystals, windows, and shields
- Over 40,000 small aperture (5-15cm) optics
- Processing throughput will be required to yield approximately 100 optics/ week and 3000 mechanical parts/week resulting in the assembly of approximately 17 optics assemblies/week for a two-year construction period

Cleanliness Requirements Mission



There are two different standards that are used to describe the cleanliness specifications

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Cleanroom Cleanliness Levels (Airborne) Fed. Std. 209E

	Measured Particle Size (Micrometers)				
Class	0.1	0.2	0.3	0.5	5
1	35	7.5	3	1	N/A
10	350	75	30	10	N/A
100	N/A	750	300	100	N/A
1000	N/A	N/A	N/A	1000	7
10000	N/A	N/A	N/A	10000	70
100000	N/A	N/A	N/A	100000	700

Class limits in particles per cubic foot of size equal to or greater than particle sizes shown.

Surface Cleanliness Levels Mil. Std. 1246C (Nonvolatile Residue)

Level	Limit, NVR mg/0.1m2*
A/100	0.01
A	1.0
B	2.0
J	25.0

*1 ft2=0.093 m2

Surface Cleanliness Levels Mil. Std. 1246C (Particulate)

Level	Particle Size, µm	Count/ ft2	Count/ 0.1m2	Count/ liter
1	1	1	1.08	10
50	5	185	179	1660
50	15	25	27	250
50	25	7.3	7.88	73
50	50	1	1.08	10
100	5	1785	1930	17850
100	15	265	286	2650
100	25	78	84.2	780
100	50	11	11.9	110
100	100	1	1.08	10
200	15	4189	4520	41890
200	25	1240	1340	12400
200	50	170	184	1700
200	100	16	17.3	160
200	200	1	1.08	10
1000	*	*	*	*

Optics

Mechanical Parts

Cleanliness Design Requirements for Full Aperture Optics Assemblies

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		Overall Budget	Process Budget	Cleanliness Verification Method
Particulate				
Mechanical Parts				
Internal Laser Cavity		Mil-Std 1246 C Level 100A -2 P/cm2		
Cleaning	10%		0.2 particles/cm2	Liquid particle counts, witness plates, tape
Assembly	30%		0.6 particles/cm2	test, process verification, QIII surface
Measurements	10%		0.2 particles/cm2	particulate counts, Black light, etc
Transportation	10%		0.2 particles/cm2	"
Storage	10%		0.2 particles/cm2	"
Installation	10%		0.2 particles/cm2	"
Operations	20%		0.4 particles/cm2	"
External - Mechanical Parts	Mil-Std 1246C	Level 500		
Optics		Mil-Std 1246C Level 50A-.2 P/cm2		
Cleaning	10%		0.02 particles/cm2	Liquid particle counts, witness plates, tape
Assembly	30%		0.06 particles/cm2	test, process verification, QIII surface
Measurements	10%		0.02 Particles/cm2	particulate counts, Black light, etc
Transportation	10%		0.02 particles/cm2	Prototypes - Cleanliness Verification
Storage	10%		0.02 particles/cm2	Measurement System (CVMS)
Installation	10%		0.02 particles/cm2	"
Operations	20%		0.04 particles/cm2	"
Non-Volatile Residues		M.S. 1246C Level A		Witness samples, statistical sampling (extraction, FTIR, elipsometry, etc.)
Volatile Organic Contamination		<Teflon (TGA-1 hr@ 100C		TGA (amount) and GCMS (content)
Gases		Ultra-pure 0.2μM		Particulate (filter test), RGA

NIF Optics Processing

Optics	No. Req.	Project Total	LLNL QC 10%	Cleaning	AR Coat	Alignment	Interf. Assembly	Cleanliness Verif. Assy	Cleanliness Req./Assy
Amplifier Slabs	3456	3802	380	Aqueous	No	Mechanical	Static/OAB	OAB/Auto	Mil-Spec 1246C Level 50A
Amplifier Blastshields	1728	1900	0	Aqueous/Heat Ultrasound	Yes/600nm	no	no	Visual	Mil-Spec 1246C Level 50A
Spatial Filter Lenses	768	845	85	Aqueous/Heat Ultrasound	Yes/1053nm	Vendor/OAB	Static/OAB	OAB/Auto	Mil-Spec 1246C Level 50A
Mirrors	1374	1586	159	Aqueous	No/HR	OAB	Static/OAB	OAB/Auto Validation	Mil-Spec 1246C Level 50A
Polarizers	192	242	24	Aqueous	No	OAB	Static/OAB	Validation	Mil-Spec 1246C Level 50A
Switch Crystals	192	211	21	Sec-Butanol Ultrasound	Yes/1053nm	OAB	Static/391 sub-assy?	Validation	Mil-Spec 1246C Level 50A
Switch Windows	384	422	42	Aqueous/Heat Ultrasound	Yes/1053nm	OAB	no	Validation	Mil-Spec 1246C Level 50A
Final Focus Lens	192	230	23	Aqueous/Heat Ultrasound	Yes/351nm	OAB	no	Validation	Mil-Spec 1246C Level 50A
KDP/KD*P Crystals (FC)	384	422	42	Sec-Butanol Ultrasound	Yes/1053/700/ 700/351nm	OAB	Static/391 sub-assy?	Validation	Mil-Spec 1246C Level 50A
Gas Box Windows	192	211	21	Aqueous/Heat Ultrasound	Yes 1053nm	Mechanical	no	Validation	Mil-Spec 1246C Level 50A
Debris Shields	192	384	38	Aqueous/Heat Ultrasound	Yes/351nm	no	no	Validation	Mil-Spec 1246C Level 50A
Diffractive Optic	192	211	21	Aqueous/Heat Ultrasound	Yes/351nm	no	no	Validation	Mil-Spec 1246C Level 50A
Phase Plates	192	211	21	Aqueous/Heat Ultrasound	Yes/351nm	no	no	Validation	Mil-Spec 1246C Level 50A
Total	9438	10677	878						

What are the likely sources of contamination during optics processing?

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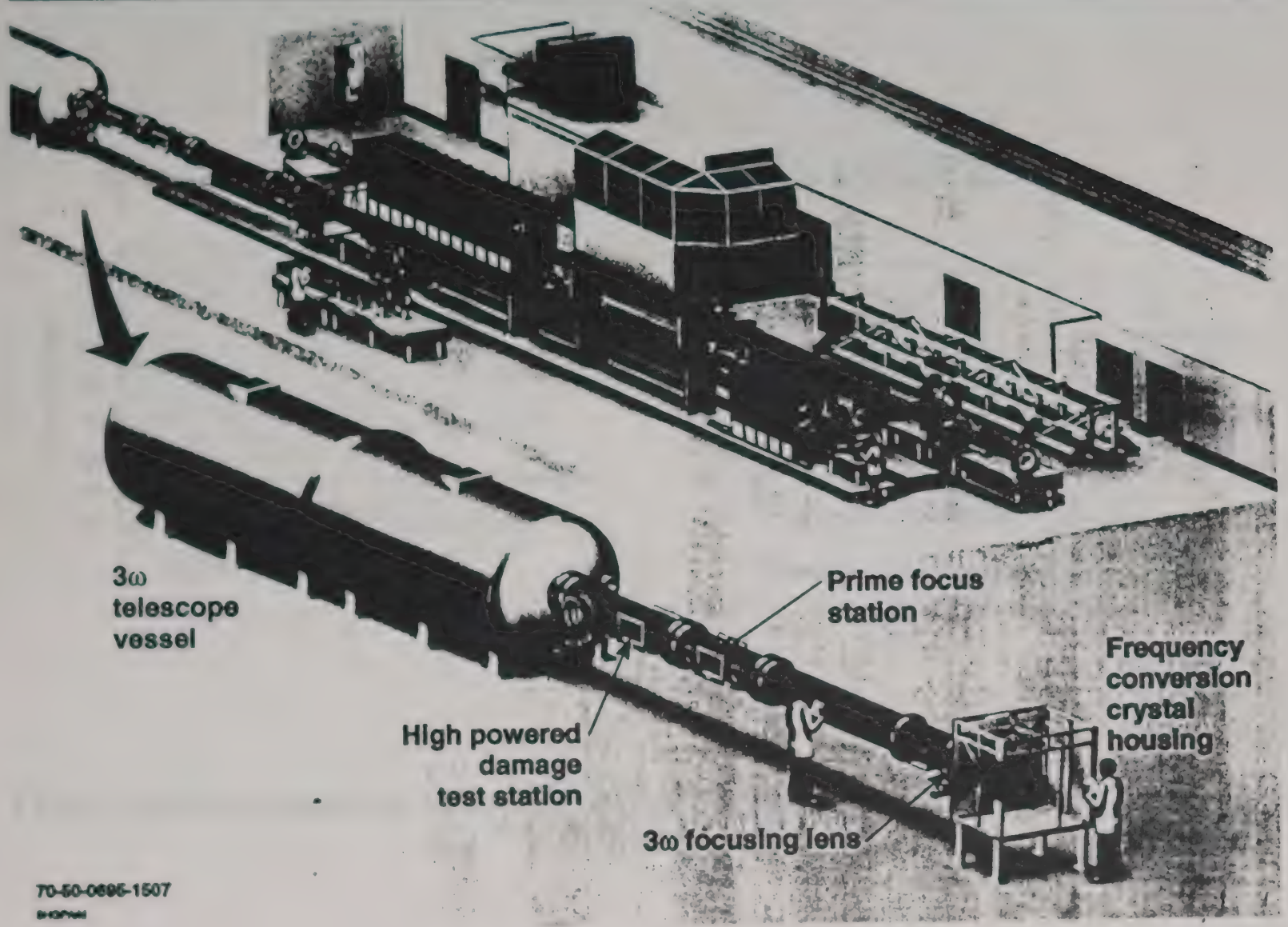
Precision Cleaning	Optics Assembly	Transportation	Storage	Operation
people contamination & errors	people contamination	people errors	vibration	insertion
equipment failures	procedures	vibration	improper packaging	vibration
inadequate cleaning	inadequate designs	improper packaging	outgassing	people errors
process materials	sliding surfaces	outgassing	leaking seals	outgassing
	inadequate cleaning		purging gases	equipment failures
	fasteners			purging gases

The QIII will be an integral part of the NIF Optics Processing QC program

- Monitor the contamination control cleaning of all NIF cleanrooms
- Witness sample monitoring of all optics processes
  - transportation
  - cleaning of optic and mechanical components
  - assembly of optic components
  - inspection of removed optic assemblies
- Monitor particulate fallout rates of cleanrooms (correlate witness plates with airborne particle counts)
- Verify surface cleanliness of parts received from vendors that have a Mil. Spec. 1246C cleanliness specification (correlate counts with Mil. Spec. 1246C)

Beamlet Phase II 3ω focal plane diagnostic station



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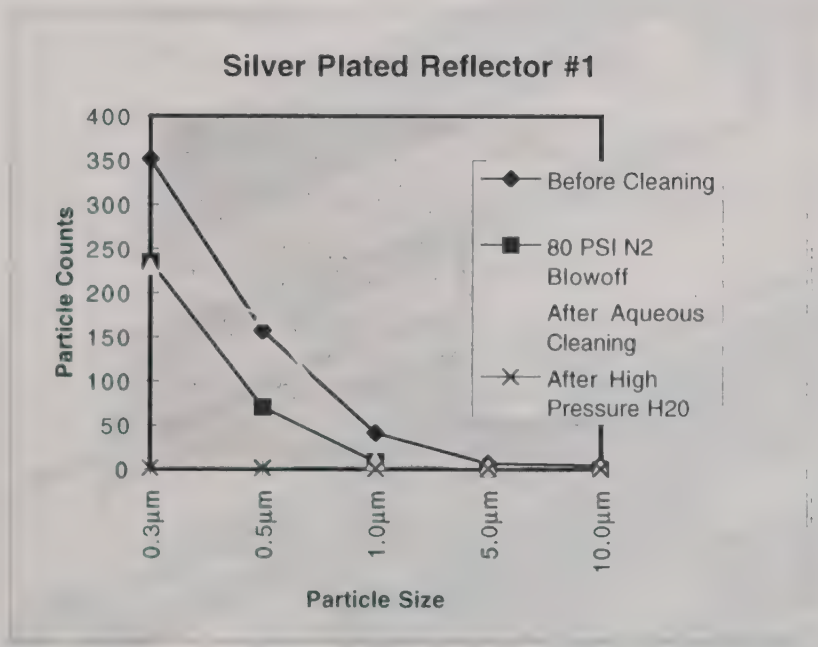
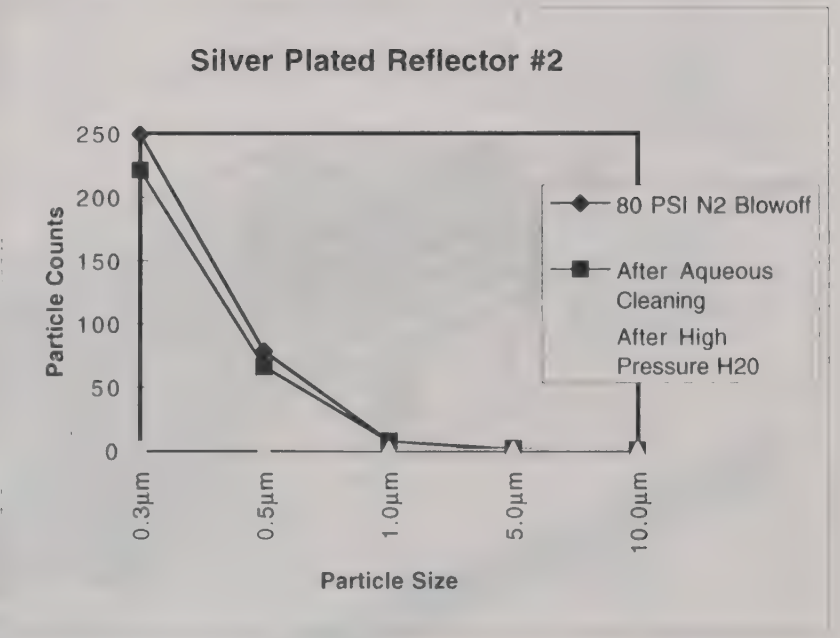
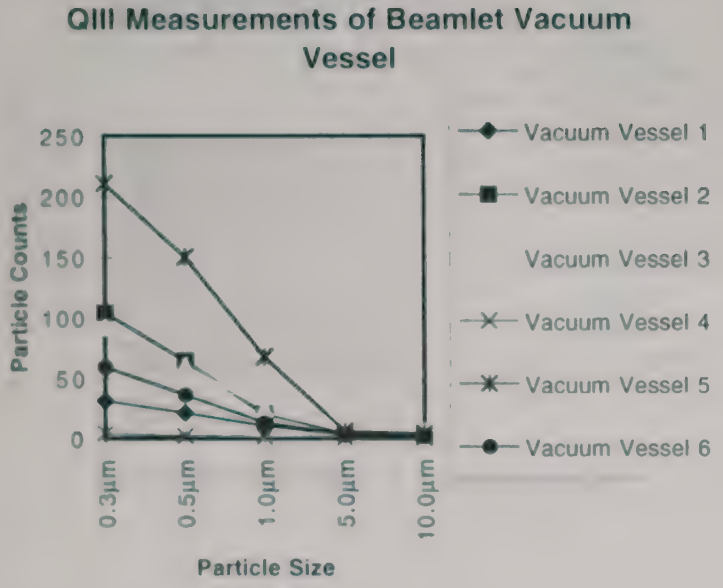
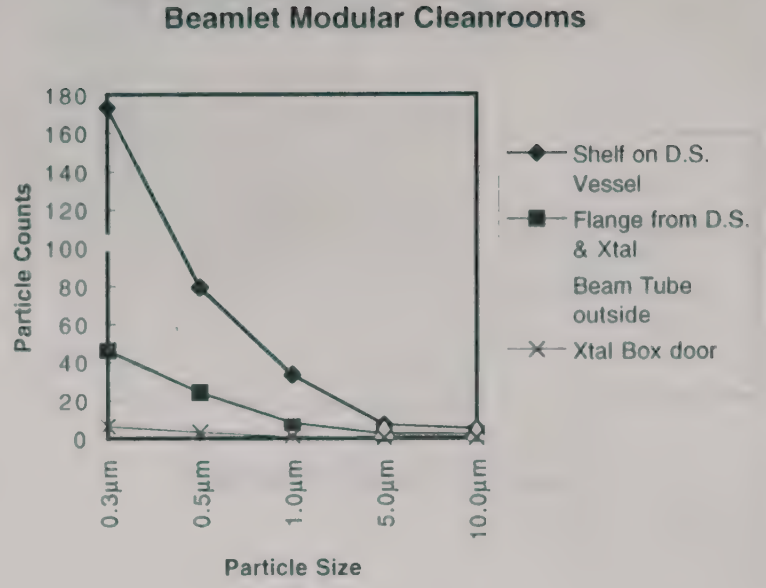
QIII Measurements of silver plated reflector



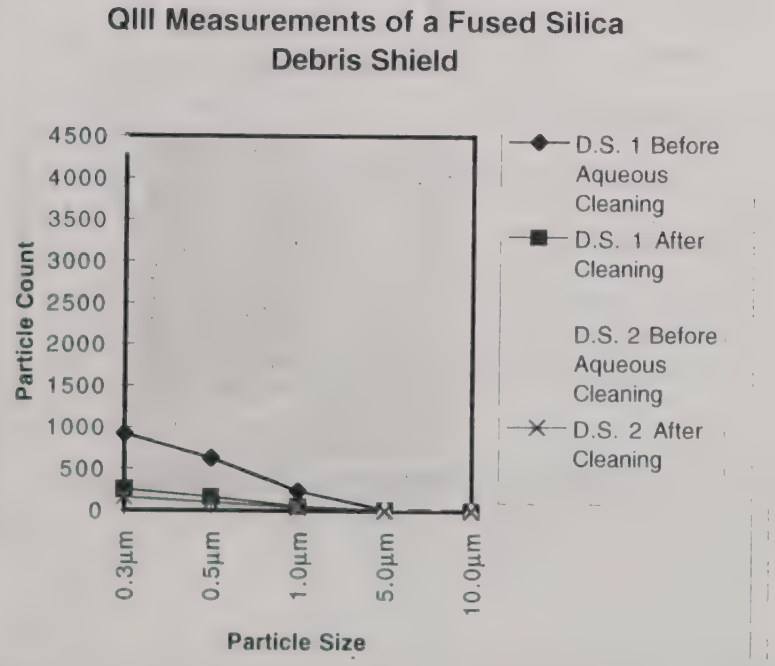


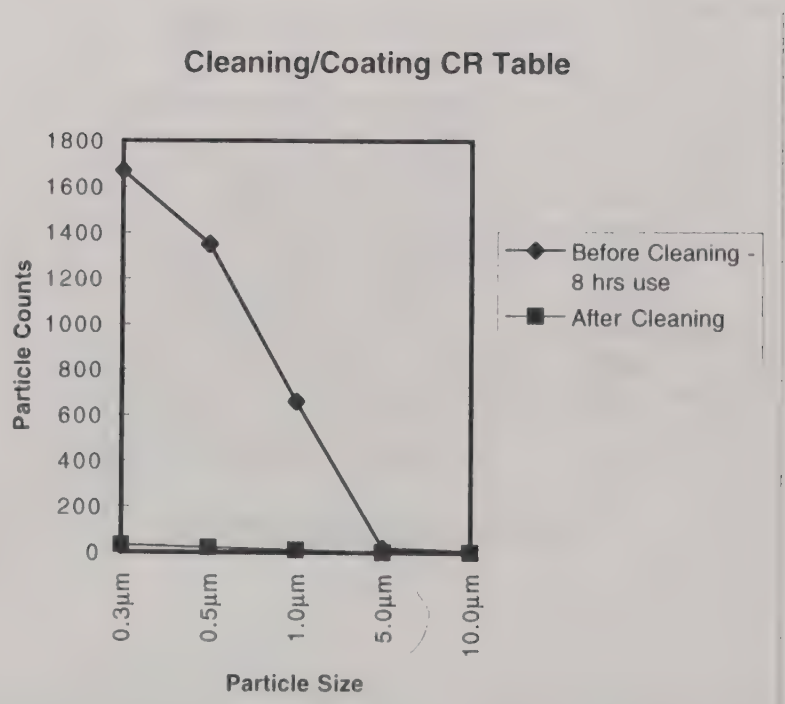
QIII Measurements in Beamlet (NIF Prototype system)





QIII Measurements of an Optic and Table in Processing Area





Dave Laube

Dave Laube is Vice President of Engineering and Technology at Kachina Testing Laboratories.

With Kachina since 1988, Dave has been responsible for the development of Kachina's Ultra High Vacuum (UHV) cleaning technologies. Utilizing his experience in research and chemical engineering, Dave has lead Kachina to the leadership position in providing state-of-the-art cleaning processes and services to semiconductor wafer fabs around the world.

In 1995, Dave designed and managed the construction of Kachina's newest cleaning facility in Austin, Texas.

A native of Akron, Ohio, Dave has worked with Goodyear Aerospace as a Process Engineer in the Engineering Materials Technology Group and has a BS in Chemical Engineering from Texas A & I University.

Kachina Testing Laboratories

- Conducting particle measurements with the Q3 since 1994
- Used as process control for monitoring particle removal from cleaned PVD shield sets
- Historically used in static mode for grit blasted surfaces (greater than 62 microinch finish)

Measurement Obstacles

- Dynamic measurements generate particles on rough surfaces
- Static measurements operator sensitive
- Sheet metal components typically display some degree of warpage

Method Development

- Eliminate operator sensitivity
- Develop device to mechanically hold probe in static and dynamic measurement modes
- Determine measurement impact of probe departure from surface
- Determine correlation of static and dynamic measurements

Test Configuration

- 3 inch diameter probe
- 3 second period
- Class 100 environment
- Test surfaces above 200 microinch surface roughness

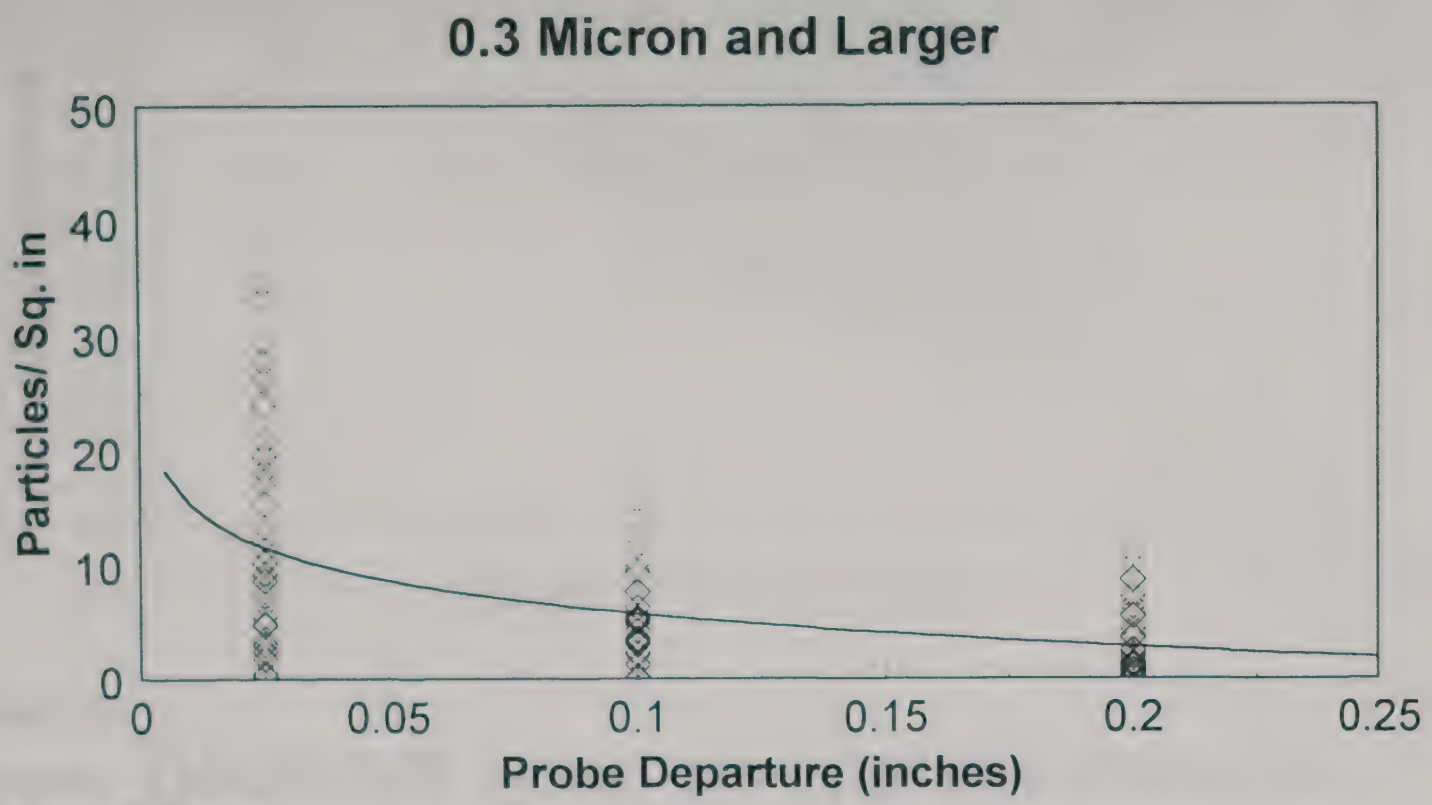
Test Configuration

- Test samples: machined, 8 inch clamp rings, one side grit blasted
- Static and dynamic measurements conducted using surface plate flat to 0.001"

Test Configuration

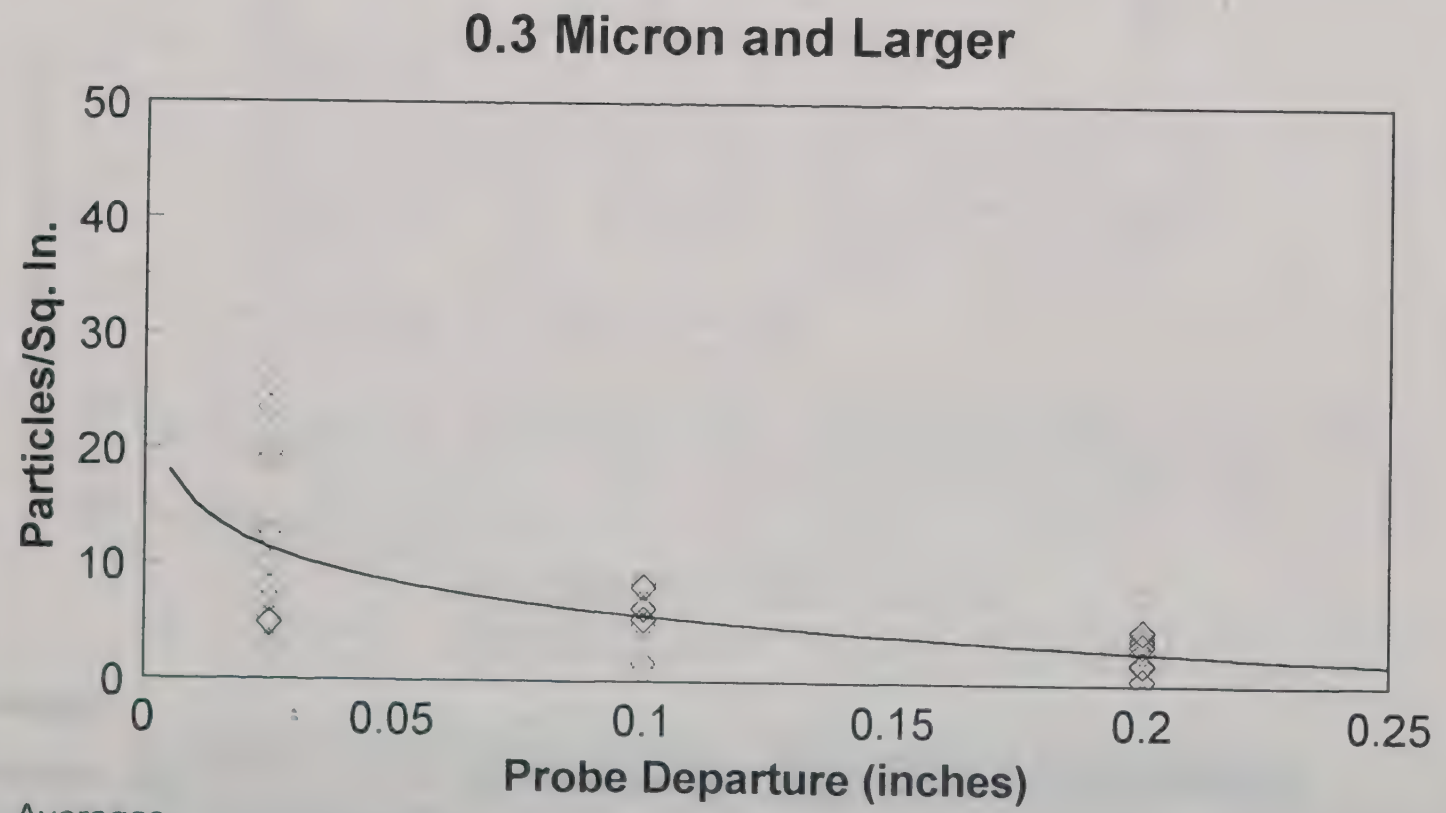
- Static and dynamic measurements obtained at 0.025", 0.100", and 0.200" probe distances
- Probe distance controlled to +/- 0.010"
- Each measurement obtained on fresh surface not previously tested

Dynamic Particle Measurements



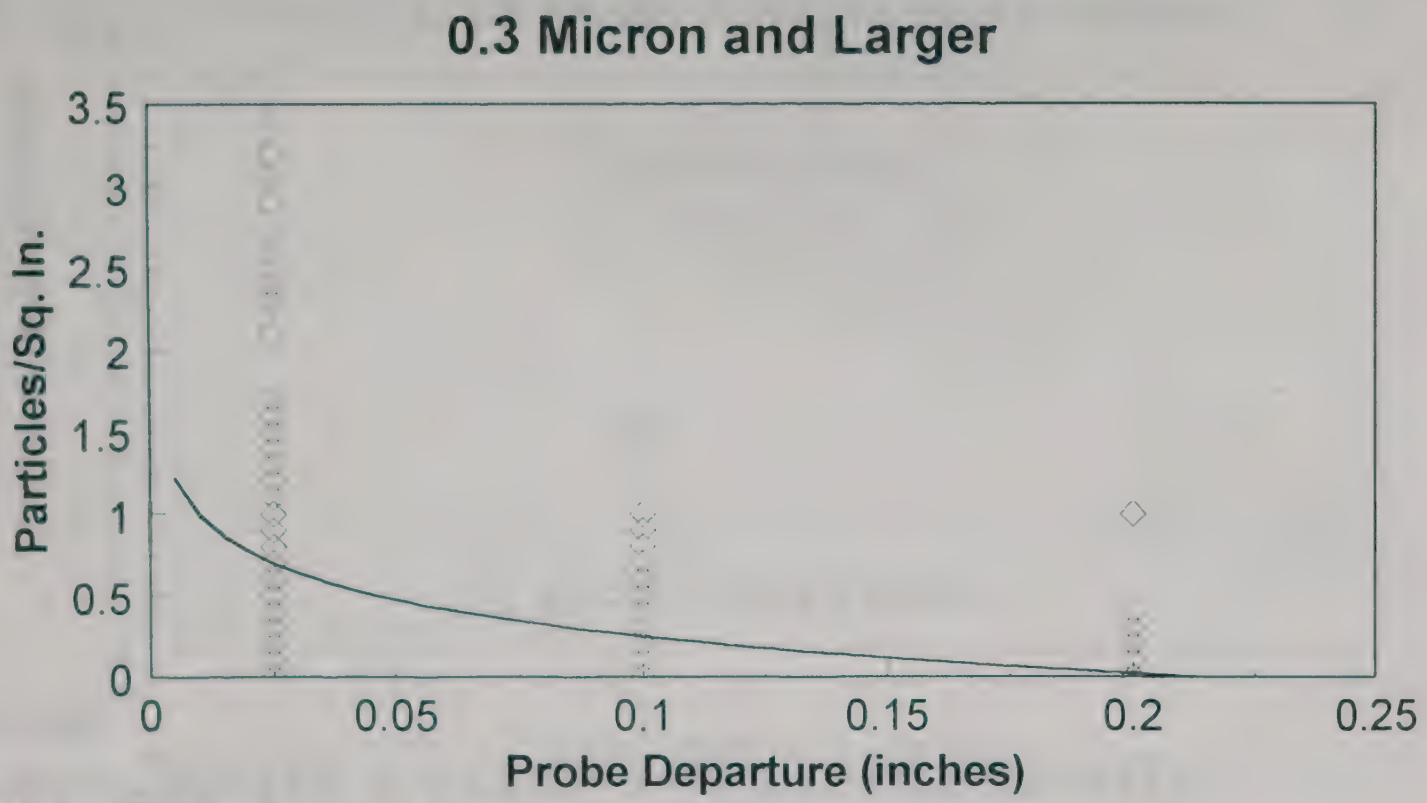
Actual Readings
Period = 3 Seconds

Dynamic Particle Measurements



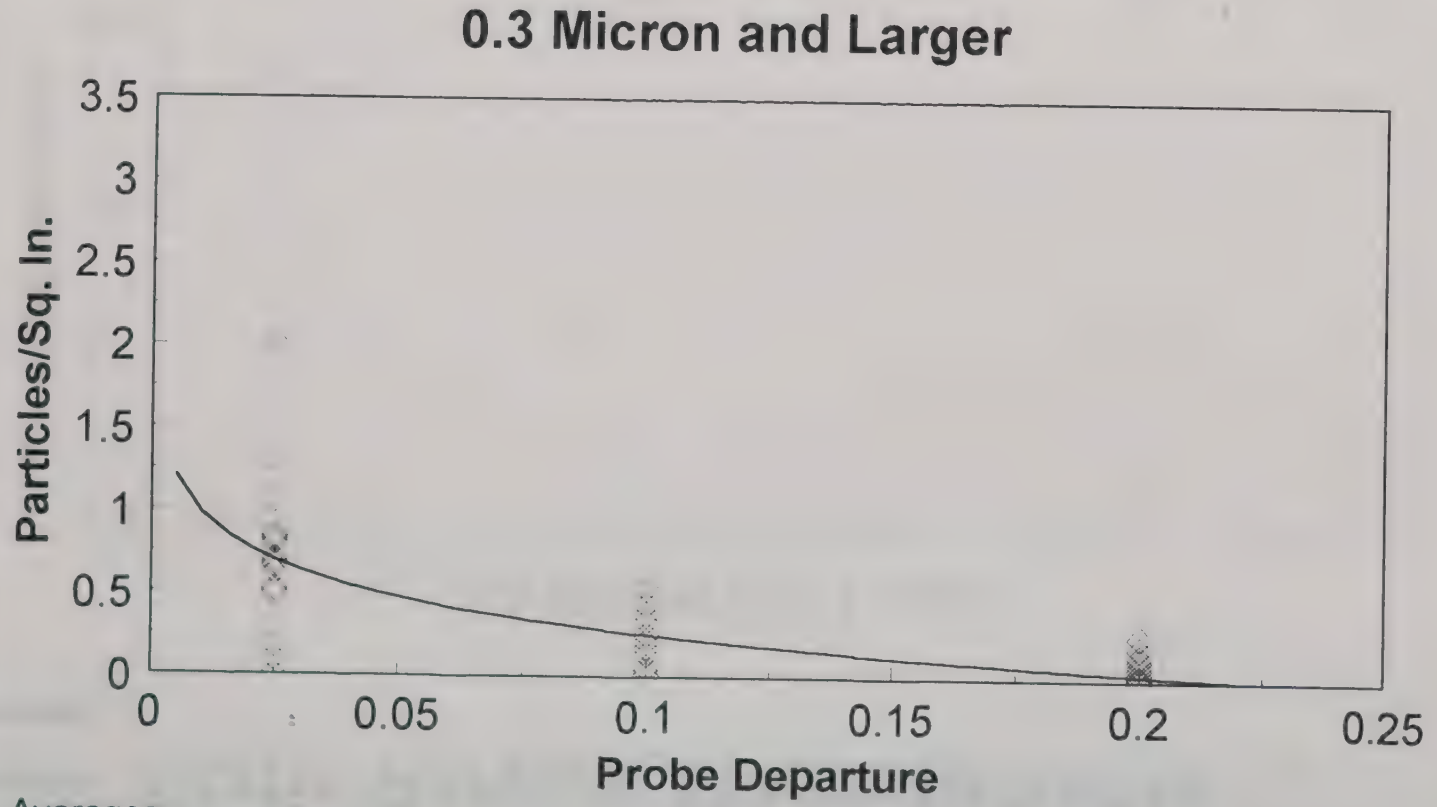
Averages
Period = 3 Seconds

Static Particle Measurements



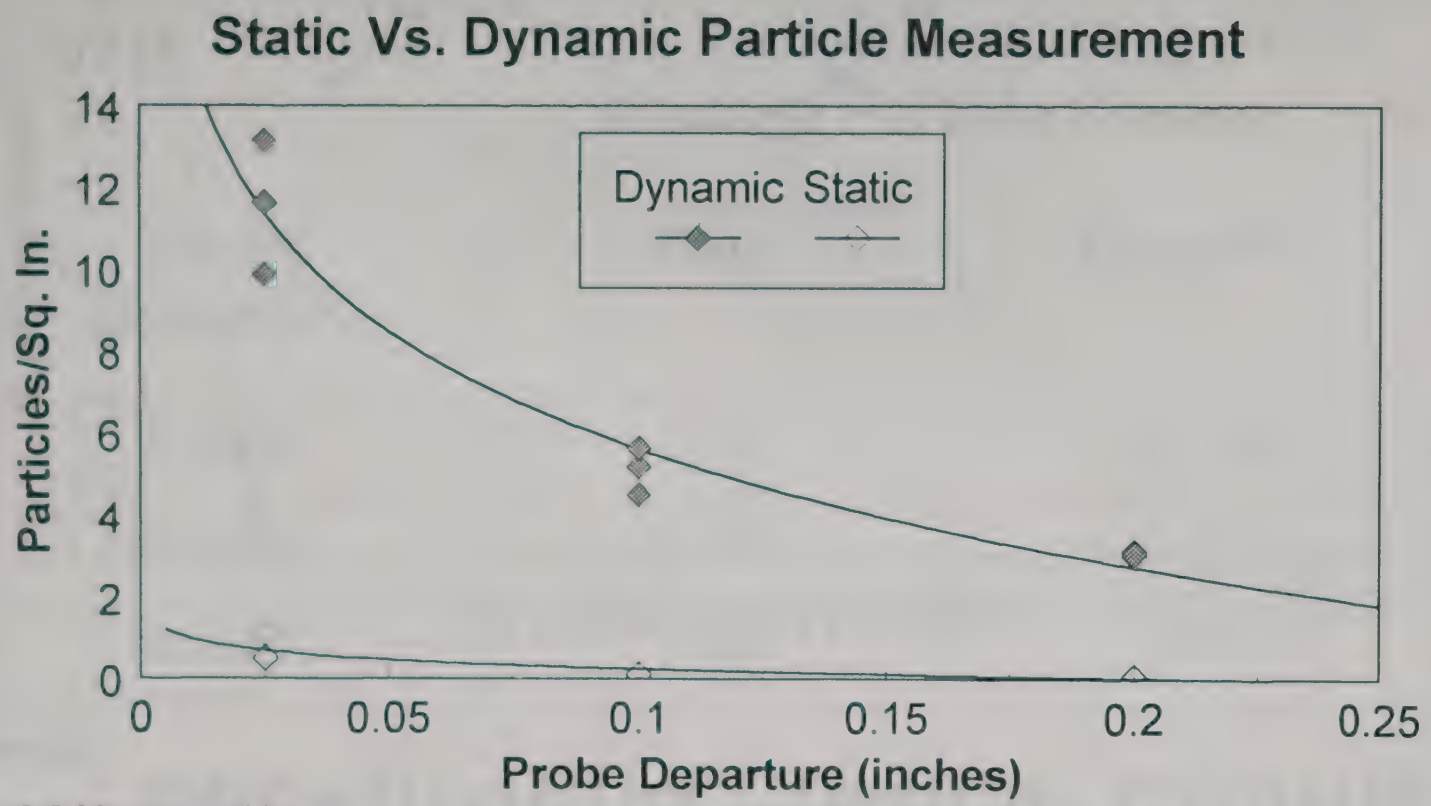
Actual Readings
Period = 3 Seconds

Static Particle Measurements



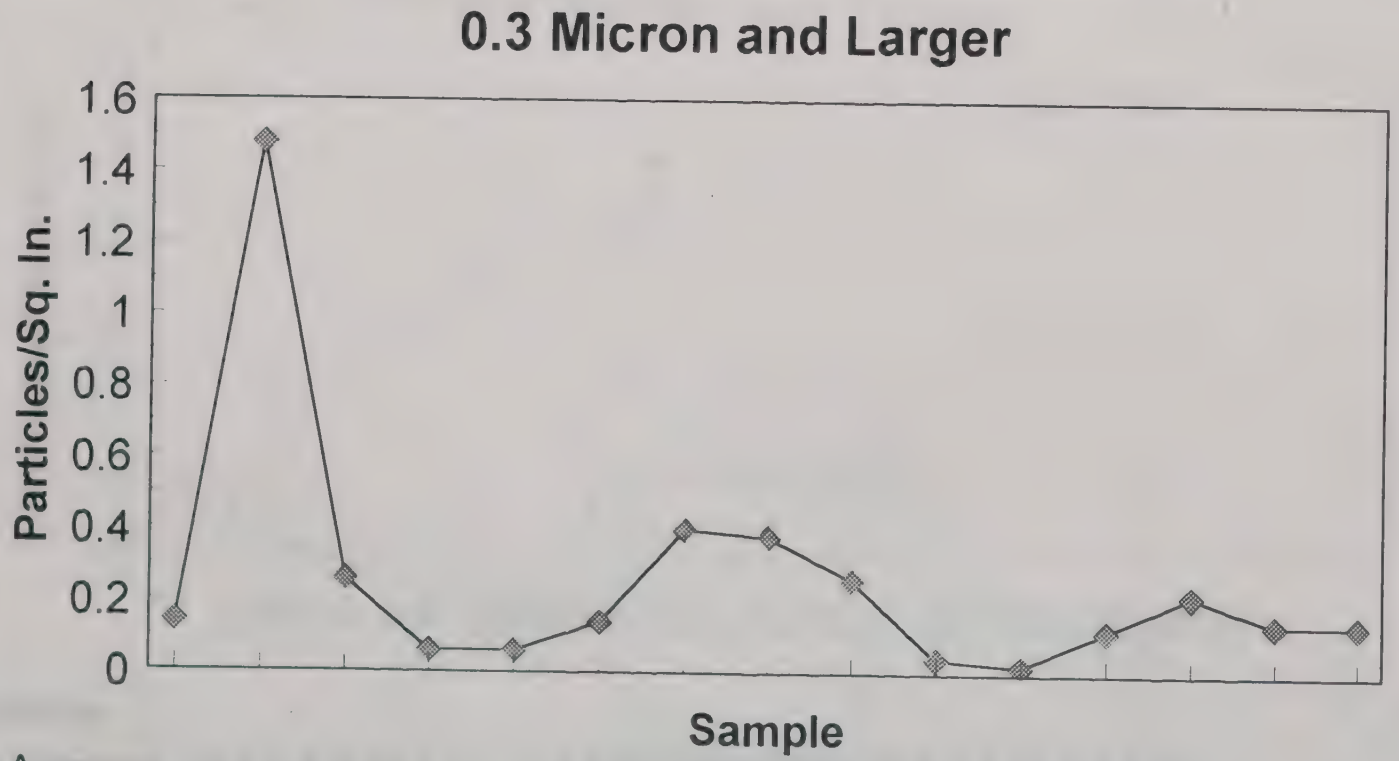
Averages
Period = 3 Seconds

Particle Measurements



0.3 Micron and Larger
Period = 3 Seconds

Background Particle Counts



Averages
Period = 3 Seconds
Dynamic

Results

Average Particle Counts

Probe Departure	Static	Dynamic
0.025"	0.73	11.55
0.100"	0.187	5.15
0.200"	0.08	3.09

Historical Particle Count Data

Static Measurement Histograms

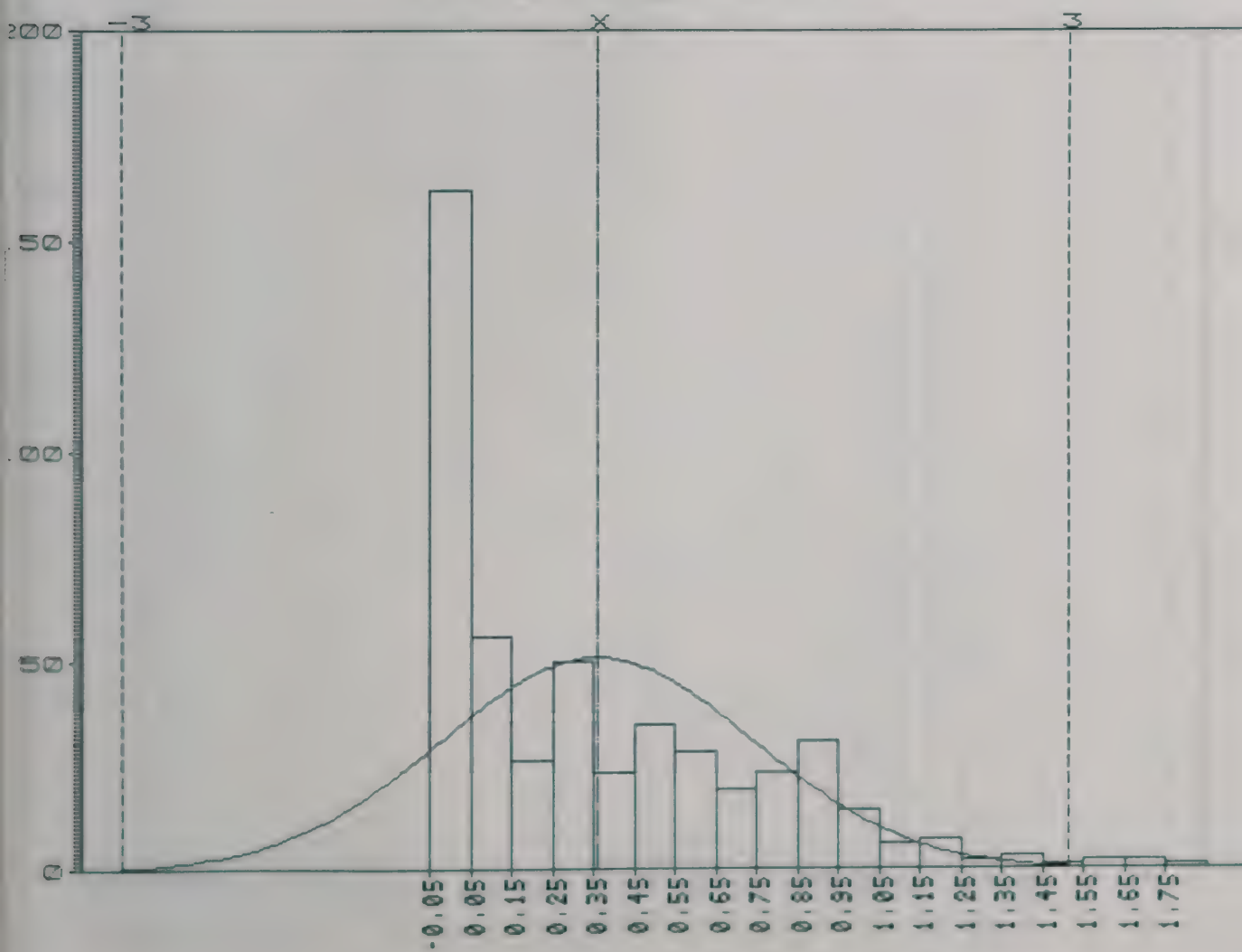
PARTICLE COUNT(STAINLESS) SHIFT1

File	:UHV_SS_1	Date:07-16-1996, 09:52:58	
Company	:KACHINA		
Plant	:Kachina Testing Labs	Part name	:
Department	:UHV	Part number	:
Machine	:	Sample frequency	:1/30
Operation	:Particle Count	Units	:sq inch
Characteristic	:Particle Count(Stainless) Shift1		

Descriptive Statistics

All (n=5)				Interval	= 0.10
491 data points				lower boundary	
Mean	= 0.36	Min. Value	= 0.0	Chi Squared	= 91.753
Sigma Indiv	= 0.38	Max. Value	= 1.8	deg. free.	= 10
Est. Sigma	= 0.23	Kurtosis	= 0.440	Conf. Level	= 95.0%
Coeff.Var.	= 1.08	Skewness	= 1.020	Not Normal	
Mean + 3s	= 1.51				
Mean - 3s	= -0.80				

Histogram



PARTICLE COUNT (ALUMINUM) SHIFT1

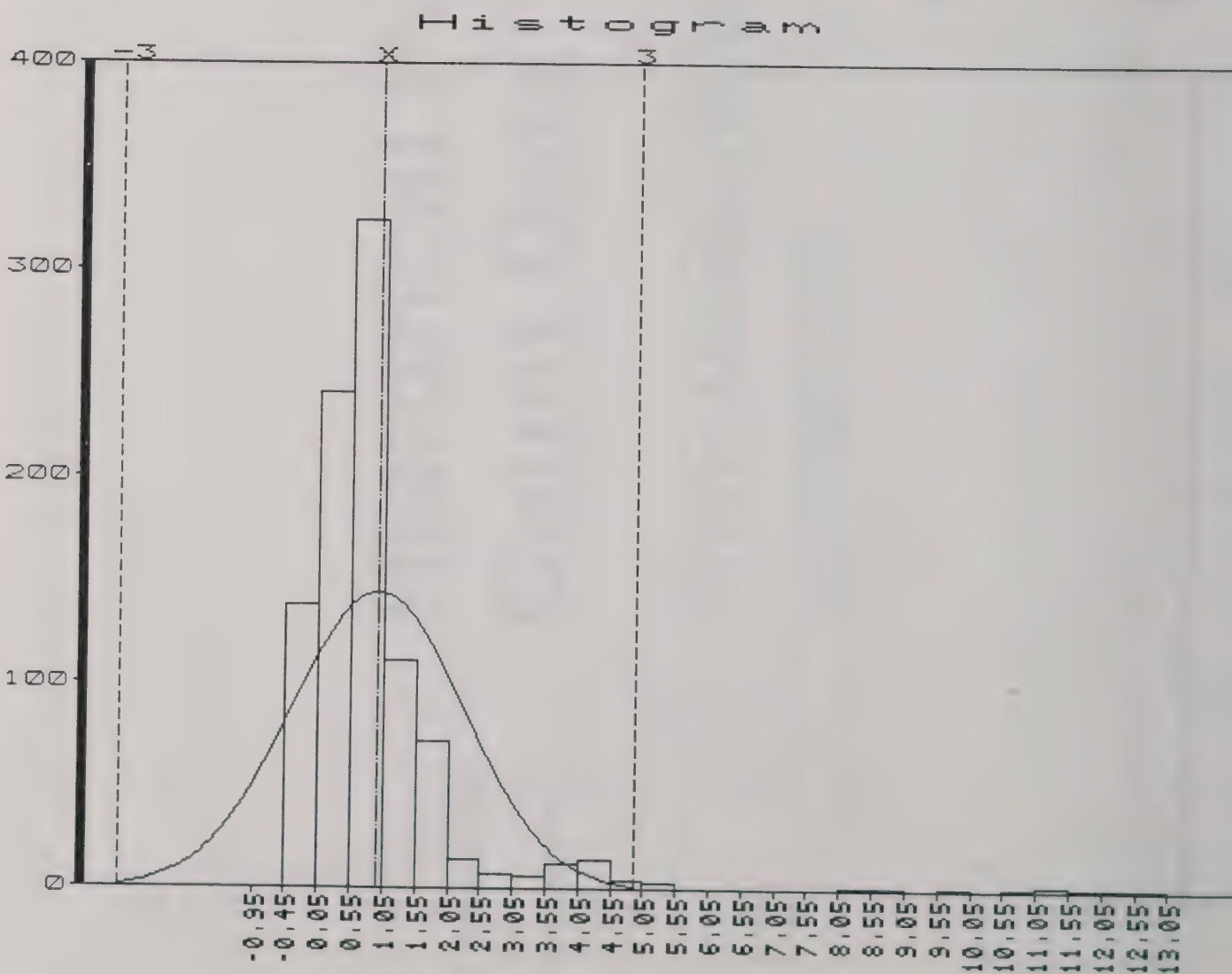
File :UHV_AL_1
Company :KACHINA
Plant :Kachina Testing Labs
Department :UHV Clean
Machine :
Operation :
Characteristic :Particle Count (Aluminum) Shift1

Date:07-16-1996, 09:53:37
Part name :
Part number :
Sample frequency:1/30 min
Units :

Descriptive Statistics

All (n=5)
955 data points

Mean	= 0.96	Min. Value	= 0.0	Interval	= 0.50
Sigma Indiv	= 1.32	Max. Value	= 12.7	lower boundary	
Est. Sigma	= 0.45	Kurtosis	= 32.556	Chi Squared	=679.412
Coeff.Var.	= 1.38	Skewness	= 4.826	deg. free.	= 8
Mean + 3s	= 4.92			Conf. Level	= 95.0%
Mean - 3s	= -3.00			Not Normal	

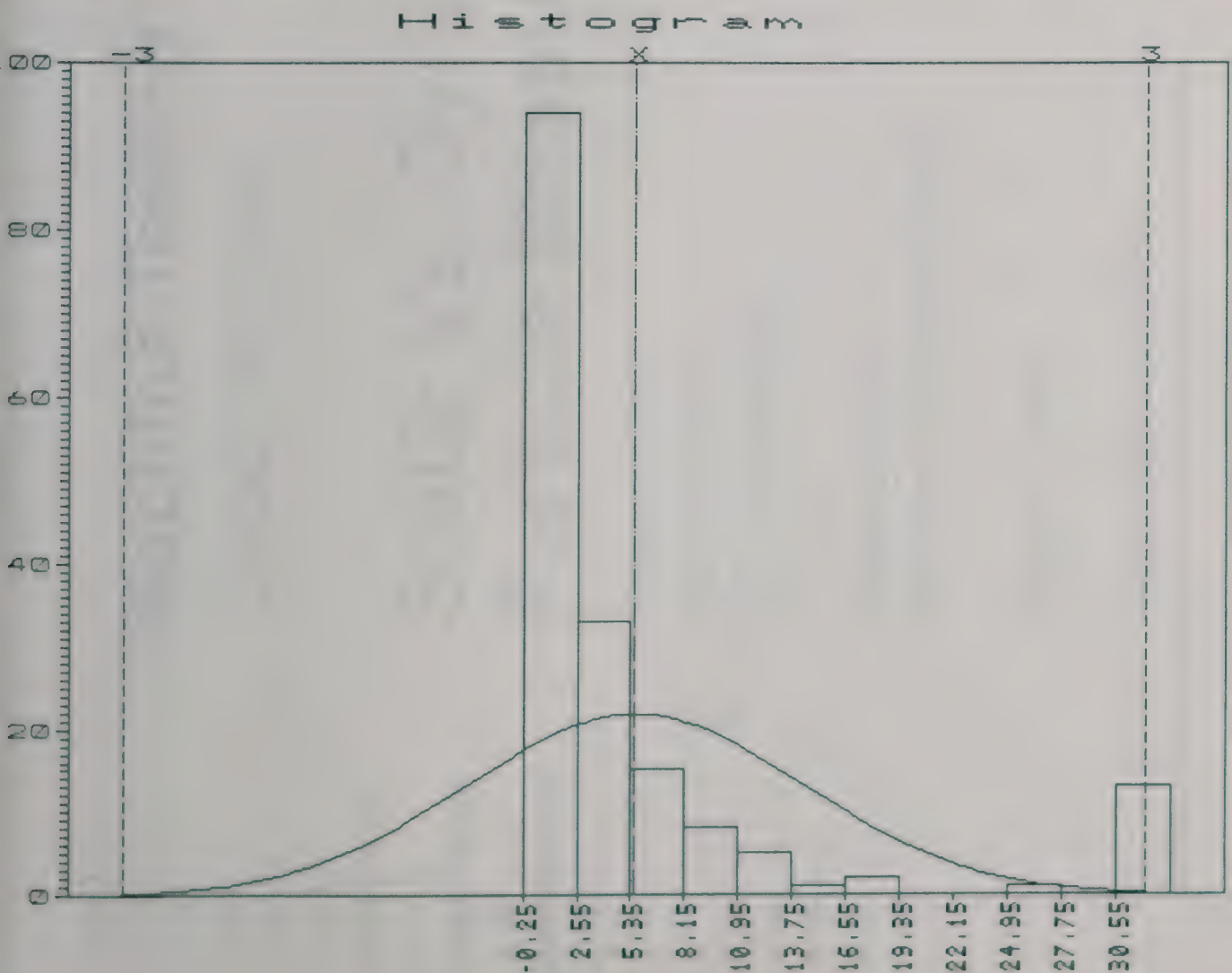


PARTICLE COUNT(ALUMINUM) SHIFT 2

File	:UHV_AL_2	Date:07-16-1996, 09:54:51	
Company	:KACHINA		
Plant	:Kachina Testing Labs	Part name	:
Department	:UHV Clean	Part number	:
Machine	:	Sample frequency	:1/30 min
Operation	:	Units	:
Characteristic	:Particle Count(Aluminum) Shift 2		

Descriptive Statistics

All (n=5)				Interval	= 2.80
172 data points				lower boundary	
Mean	= 5.57	Min. Value	= 0.0	Chi Squared	= 72.800
Sigma Indiv	= 8.83	Max. Value	= 33.3	deg. free.	= 5
Est. Sigma	= 2.72	Kurtosis	= 4.509	Conf. Level	= 95.0%
Coeff.Var.	= 1.59	Skewness	= 2.353	Not Normal	
Mean + 3s	= 32.05				
Mean - 3s	= -20.92				



PARTICLE COUNT(STAINLESS) SHIFT2

File :UHV_SS_2
Company :KACHINA
Plant :Kachina Testing Labs
Department :UHV Clean
Machine :
Operation :
Characteristic :Particle Count(Stainless) Shift2

Date:07-16-1996, 09:55:30
Part name :
Part number :
Sample frequency:1/30
Units :

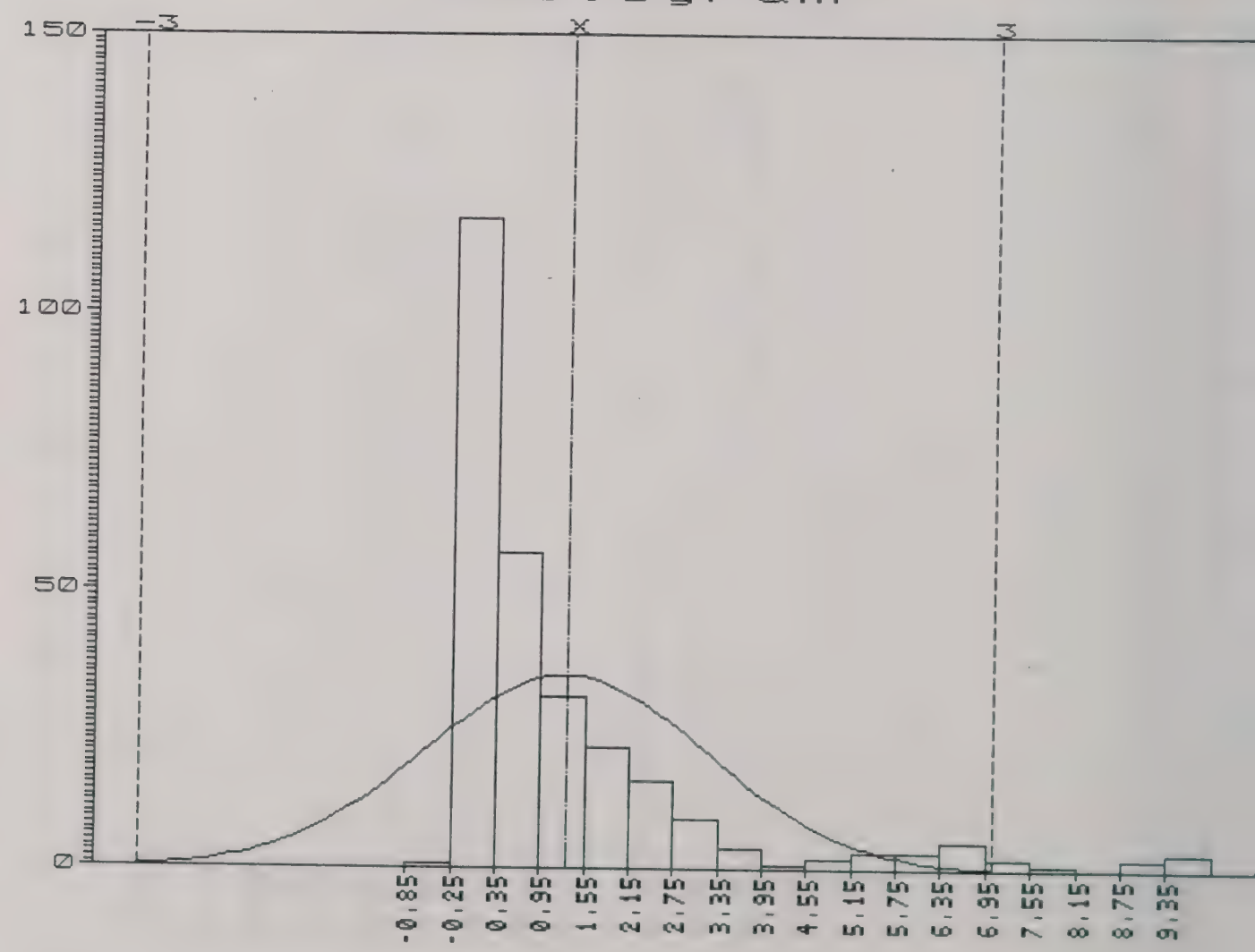
Descriptive Statistics

All (n=5)
279 data points
Mean = 1.29
Sigma Indiv= 1.91
Est. Sigma = 1.16
Coeff.Var. = 1.48
Mean + 3s = 7.03
Mean - 3s = -4.44

Min. Value = -0.8
Max. Value = 9.9
Kurtosis = 6.075
Skewness = 2.423

Interval = 0.60
lower boundary
Chi Squared=420.694
deg. free. = 8
Conf. Level= 95.0%
Not Normal

Histogram



Kachina Testing Laboratories

Static Vs. Dynamic Particle Measurements

Prepared by
David Laube
V.P. Engineering

Presented to
Dryden Q 3 Users Group

July 18, 1996

San Francisco, CA

Michael S. Gatov

Michael Gatov is currently a Manager of Contamination Control Engineering at Akashic Memories. He is responsible for founding and running the Contamination Control group and upgrading and running the Analytical Laboratory.

He also is responsible for improving product yields and improving the cleanliness of the manufacturing cleanrooms including the design and installing an On-line Contamination Monitoring System. Efforts have been geared towards equipment modification, cleanroom facilities alterations, and operator training.

Michael is responsible for implementing SPC into contamination control, and meeting all ISO-9000 requirements. During the first three months, the yield savings from his group completely paid for the department's salaries and equipment for two (2) years.

Before coming to Akashic Memories in March 1994, he was Manager of Contamination Control Engineering at Komag Incorporated.

Michael received his degree in Mechanical Engineering from Brigham Young University, ProvoUtah in 1981. He was also a Research Assistant studying the sound spectra of control valves and a thermodynamics laboratory instructor at Brigham , Young University.

Dryden QIII Gage Capability Study for Refining Cleaning Techniques

Michael S. Gatov
Akashic Memories, Inc.
July 18, 1996

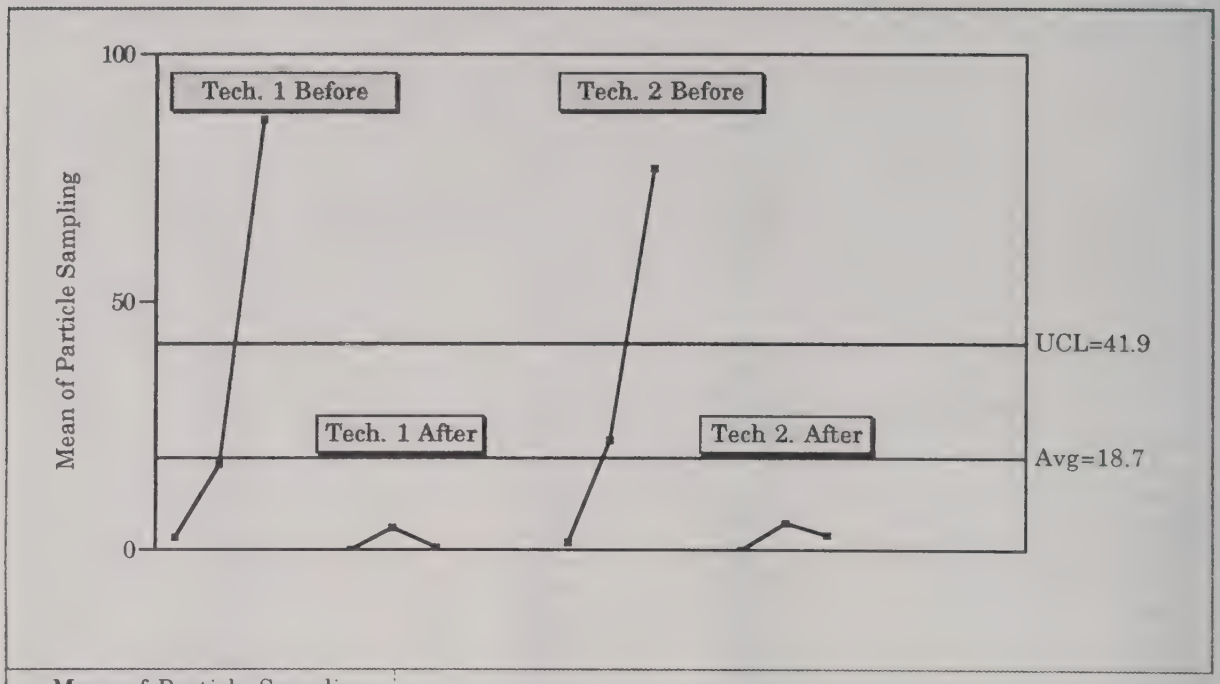
Dryden QIII is "Qualitative"

- Test - Retest error varied from: 1.4 to 50 particles/sq. in.
- Effective Resolution varied from: 1 to 34.8 particles / sq. in.

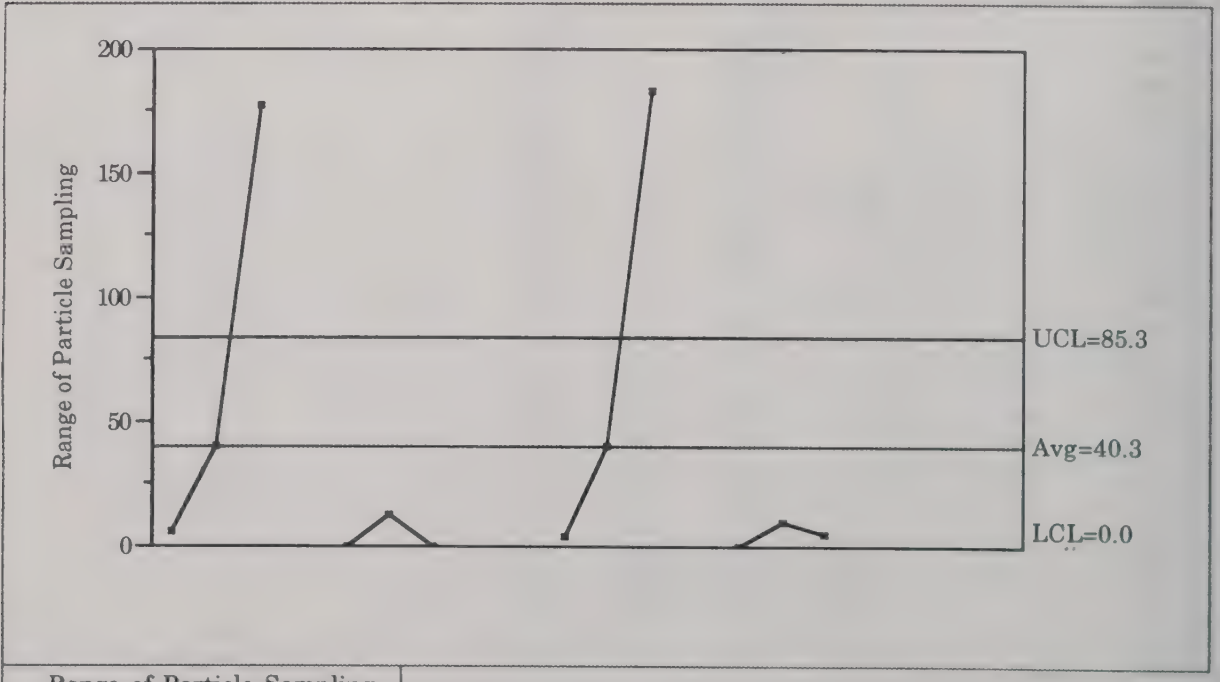
Effectiveness of Careful Cleaning

- Check Bias between "Before" and "After" conditions.
- Check Bias between Technicians.

Sub-Optimal Environment --- Effectiveness of Careful Cleaning

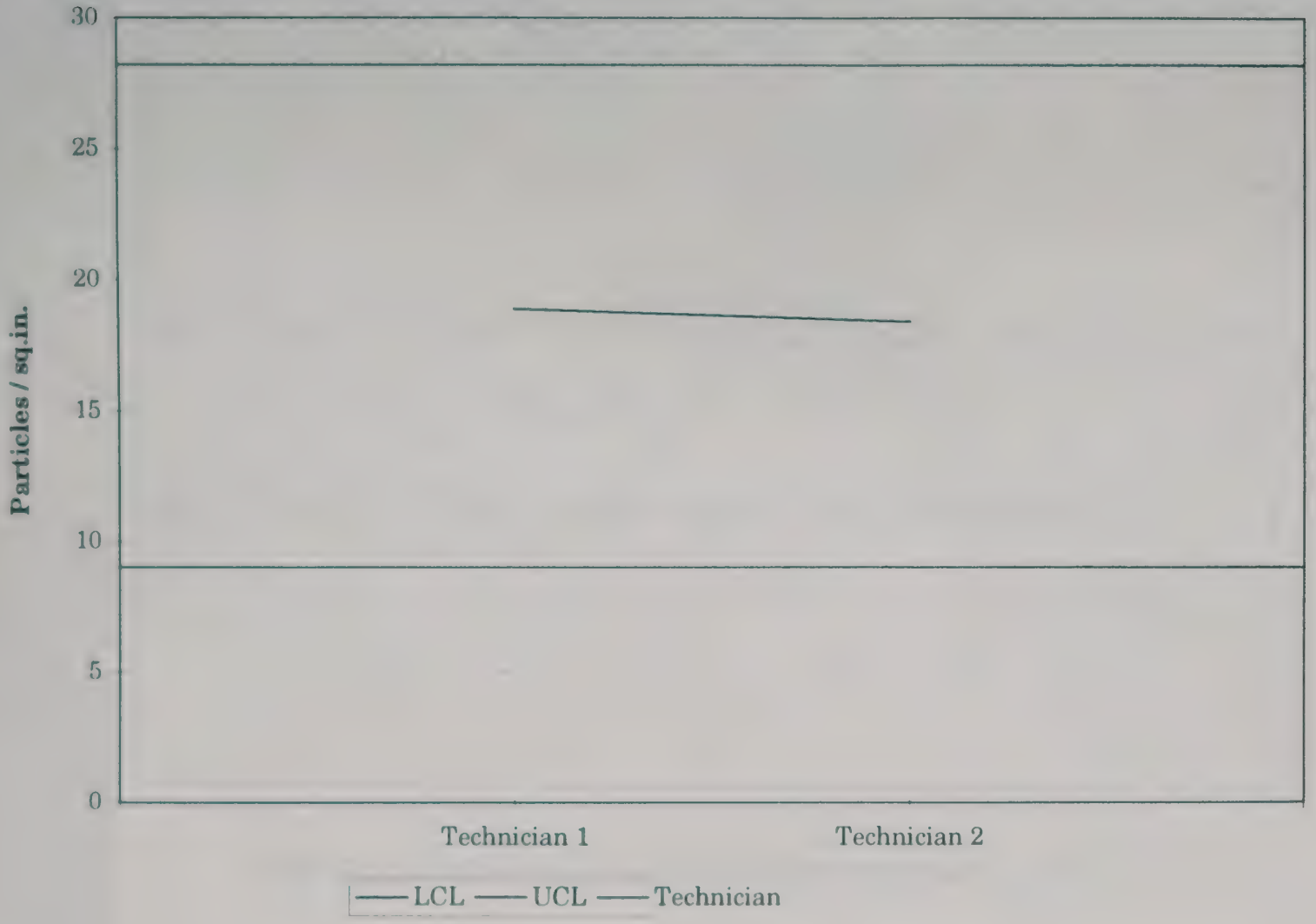


Mean of Particle Sampling

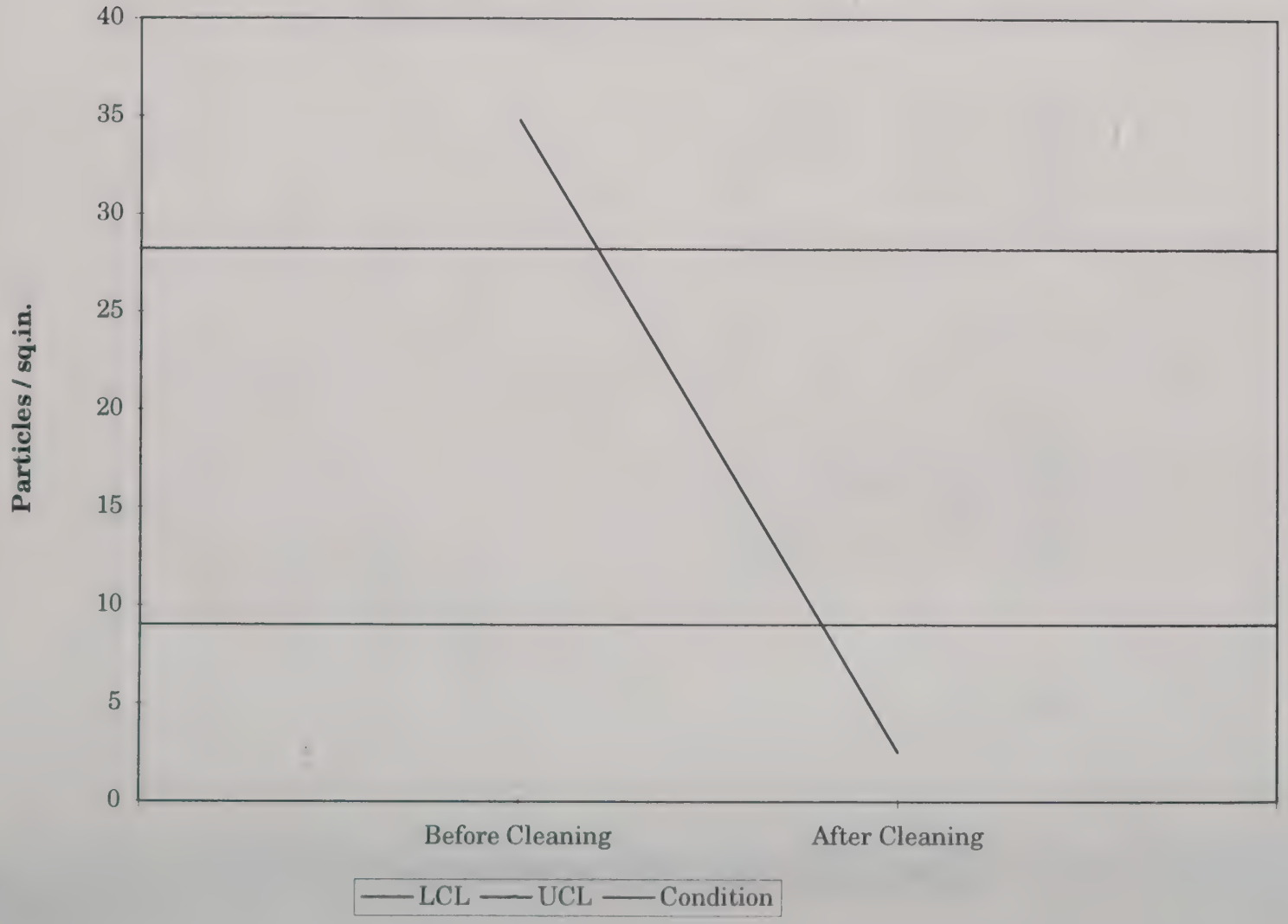


Range of Particle Sampling

Operator Bias Effects Chart



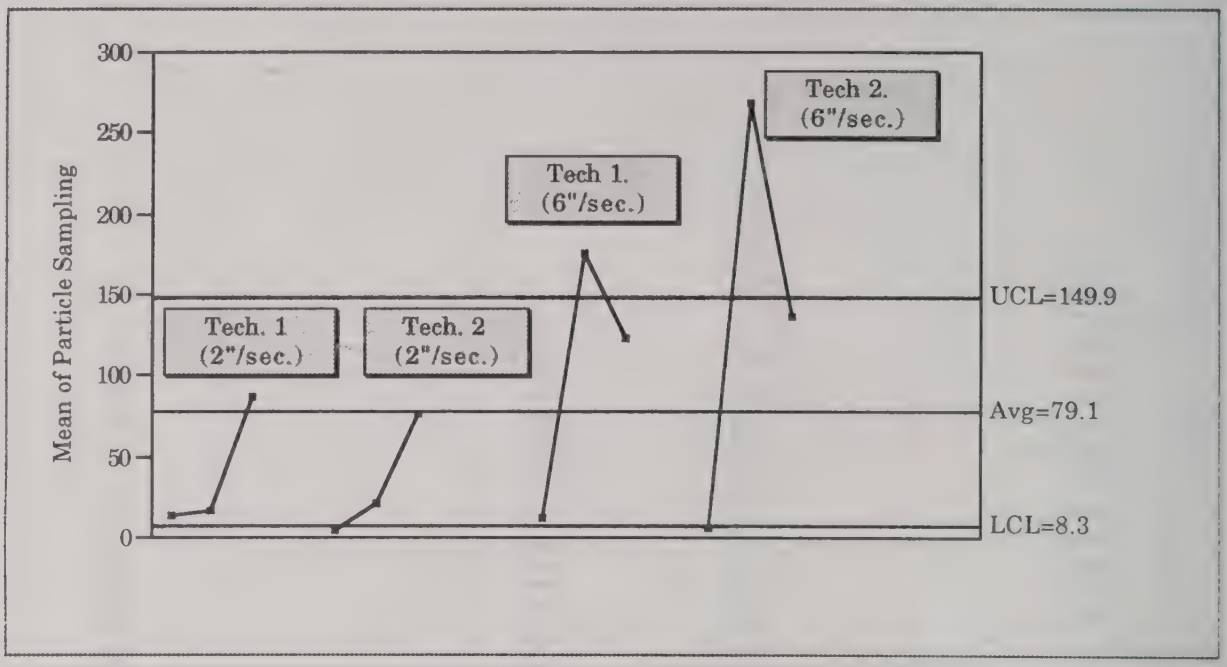
Effectiveness of Cleaning Bias Effects Chart

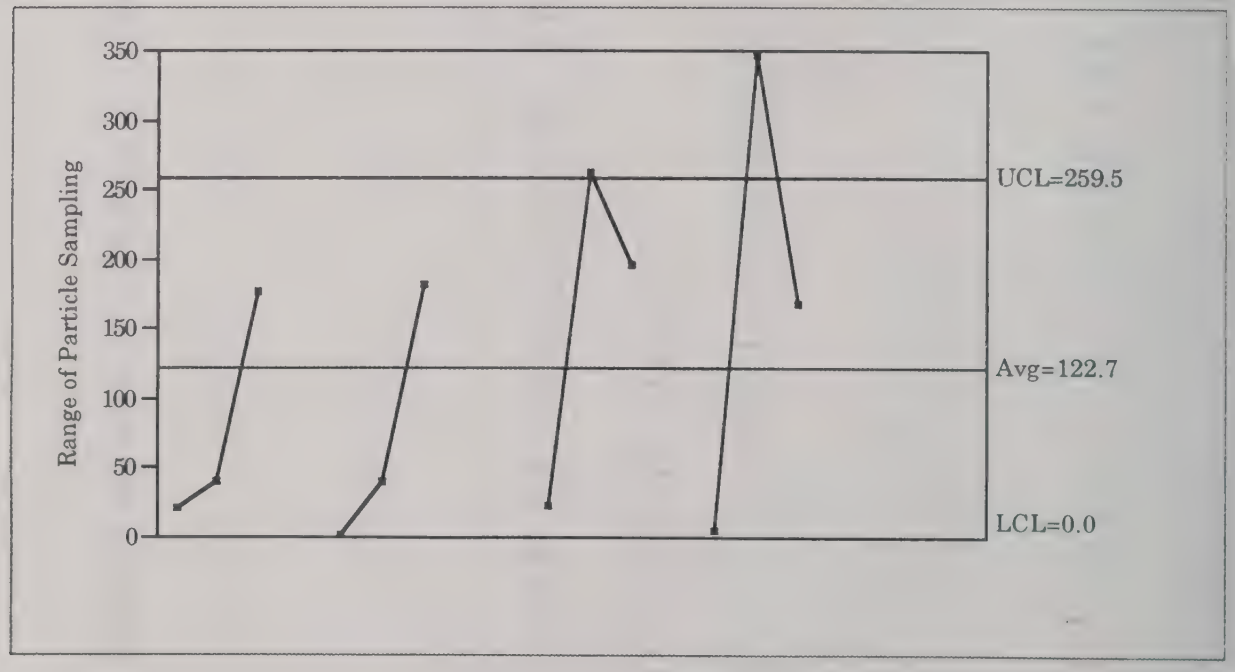


Effect of Speed of Sampling

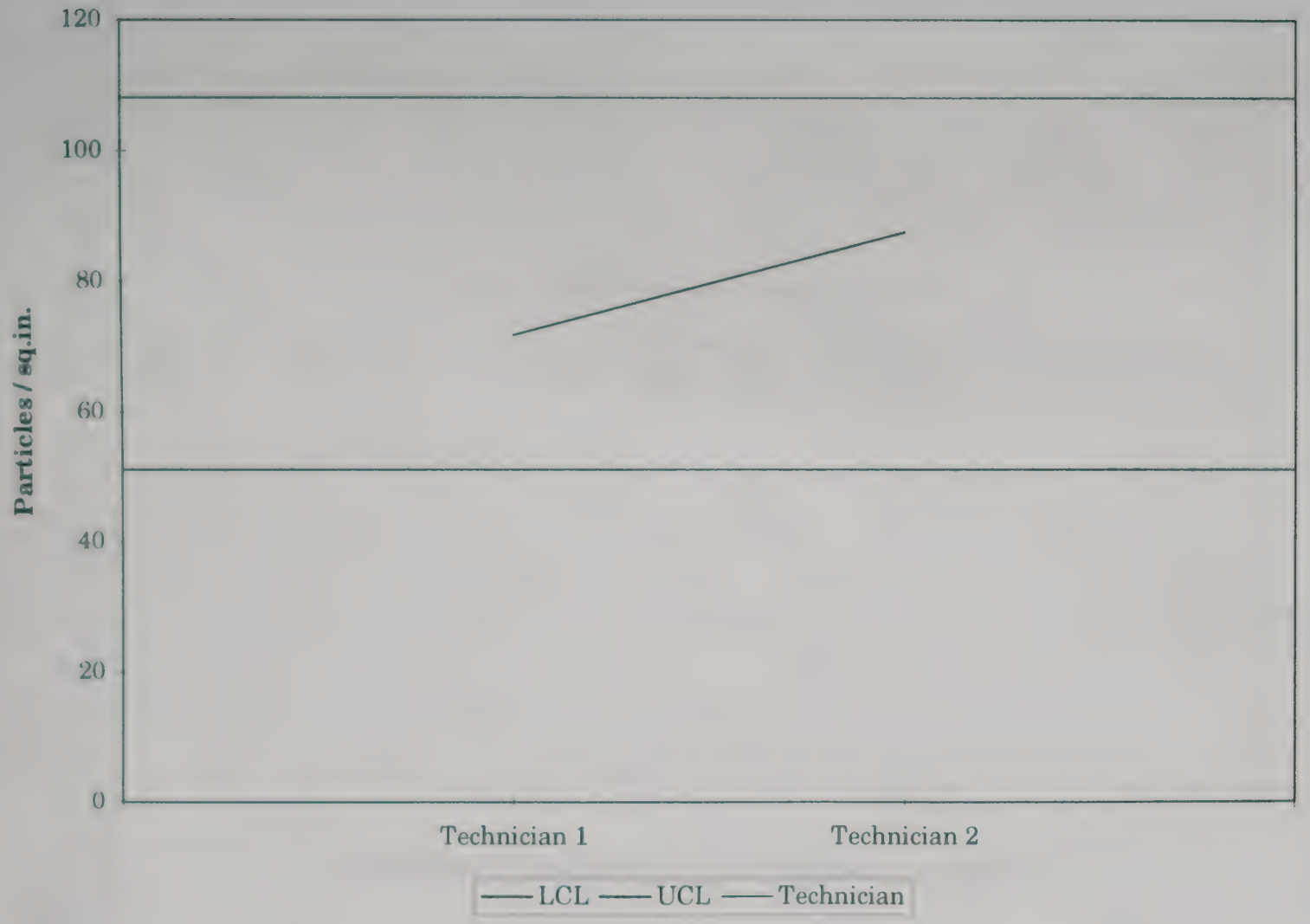
- Check Bias between 2"/sec. and 6"/sec. sampling speeds.
- Check Bias between Technicians.

Sub-Optimal Environment --- Effect of Sampling Speed

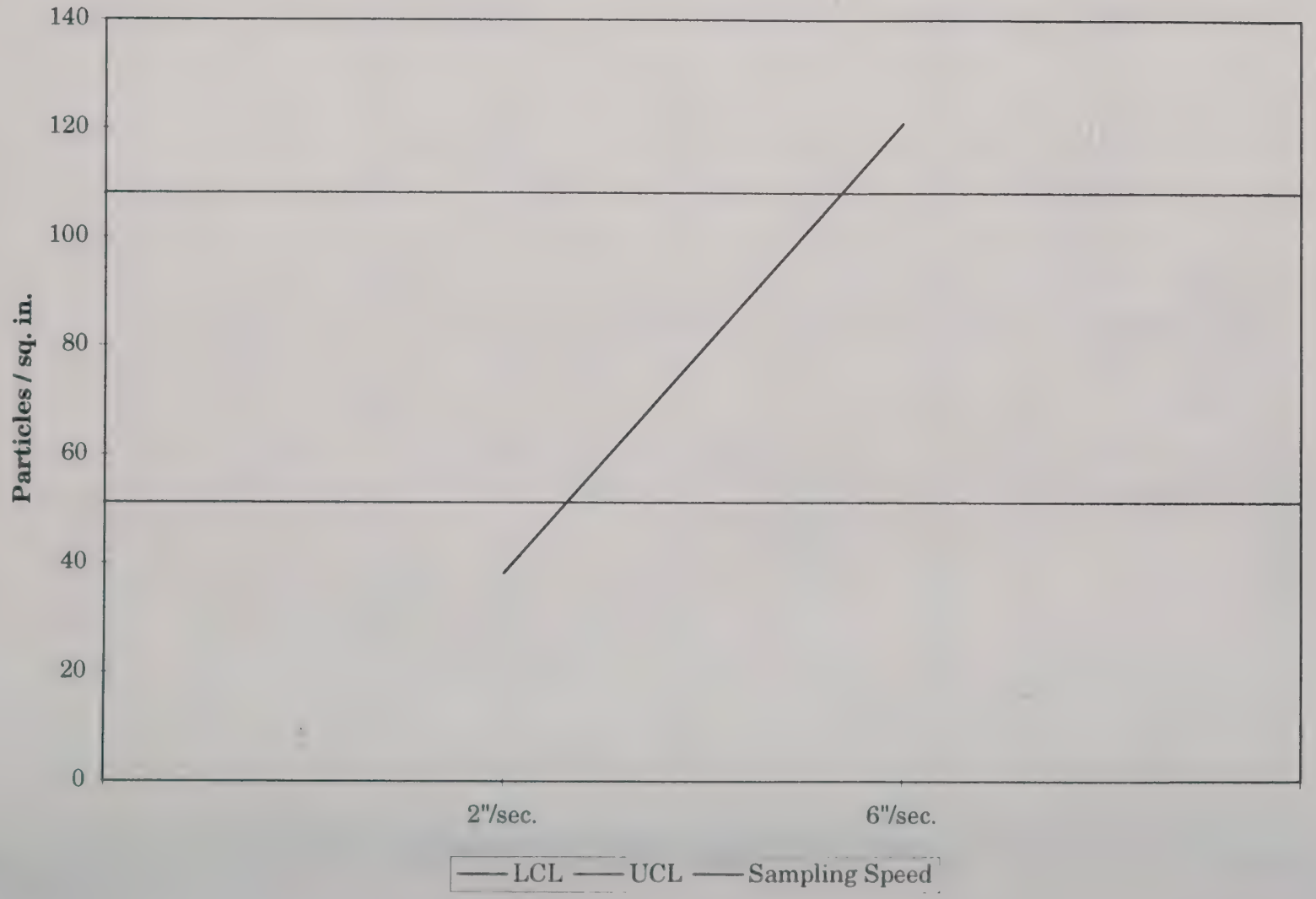




Operator Bias Effects Chart



Sampling Speed Bias Effects Chart



Effect of Different Cleaning Techniques

- Compare "Careful" to "Poor" Cleaning Techniques.

Different Cleaning Techniques

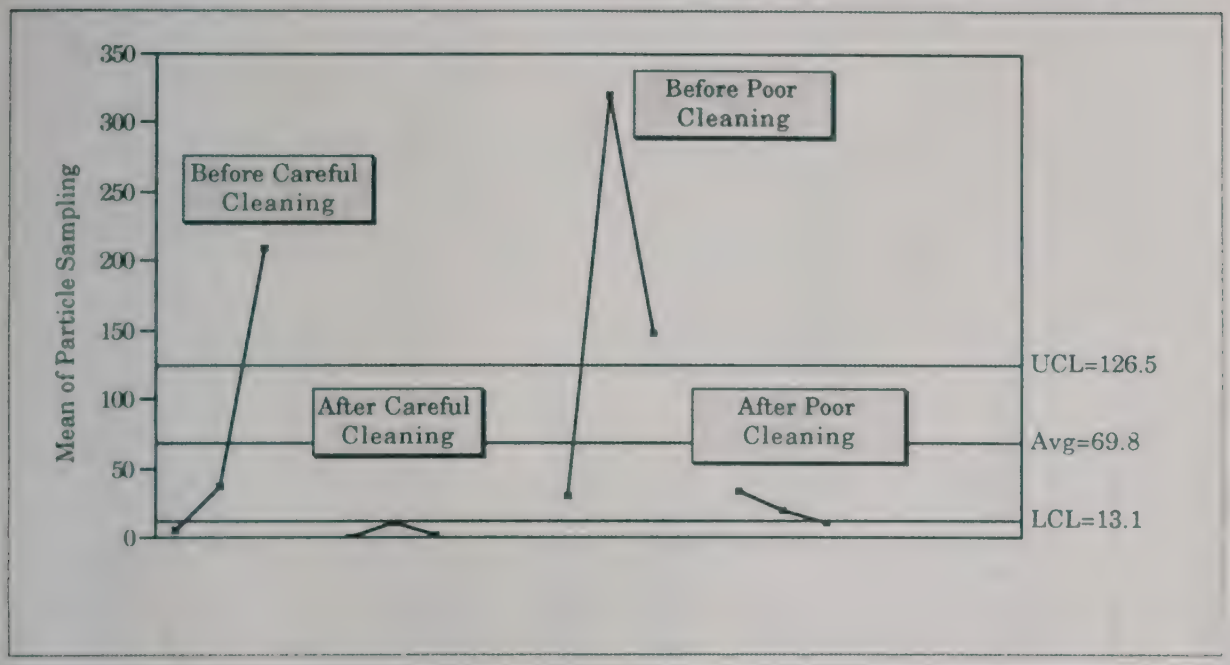
Optimal

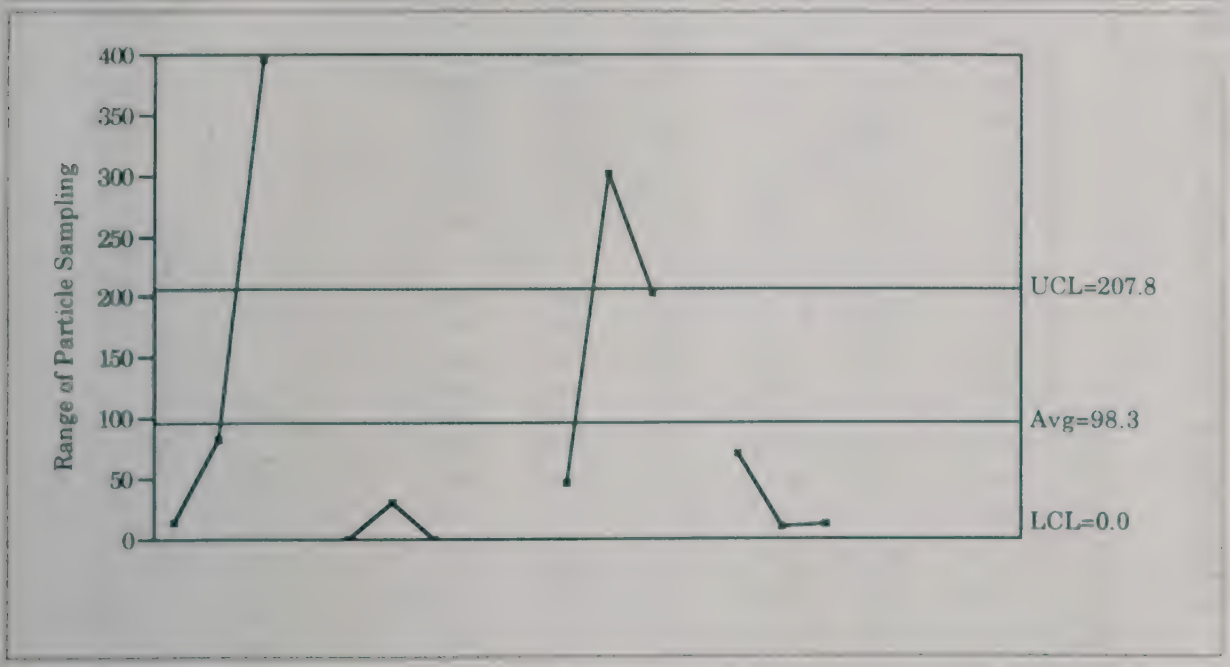
- 6”/sec. wiping speed.
- Overlapping strokes.
- Refolding wiper after each stroke.
- Change wiper after 4 strokes.

Sub-Optimal

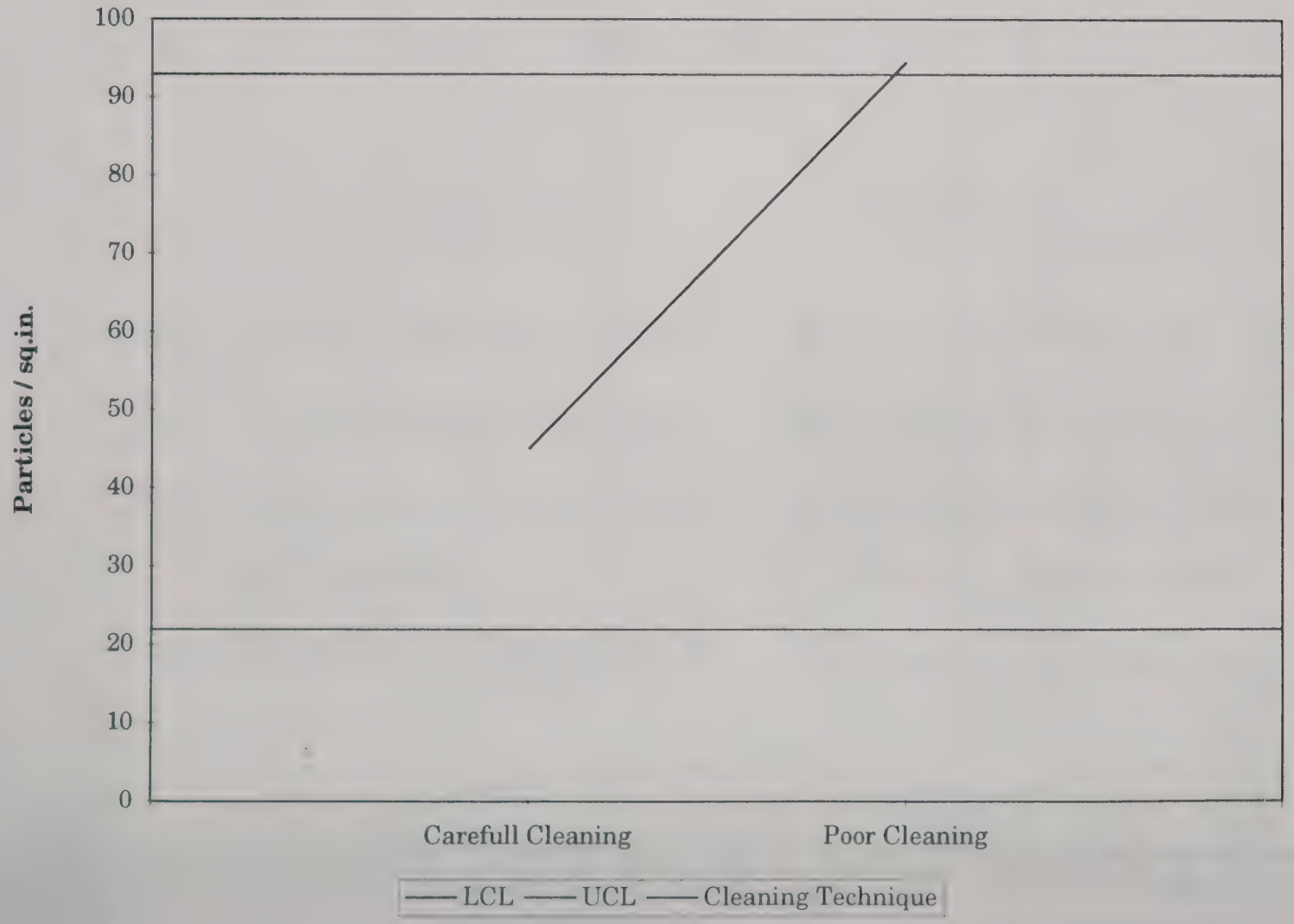
- 12”/sec. wiping speed.
- Contiguous strokes.
- Refold wiper once during operation.
- Use single wiper.

Sub-Optimal Environment --- Effect of Cleaning Technique





Cleaning Technique Bias Effects Chart



Summary

- Dryden QIII is “qualitative”.
- Dryden QIII is “speed sensitive”.
- Operator Bias is not an issue.
- Dryden QIII can help train Operators in proper cleaning techniques.
- Dryden QIII can aid in technique refinement.

Jack Livingston

Jack Livingston has worked in Motorola manufacturing organizations since 1973. Last year he completed a tour at SEMATECH involving projects in the Contamination-Free Manufacturing and Factory Integration thrusts.

He is now in Contamination Control in MOS 12, Chandler, Arizona.

He has authored several articles on defect and contamination reduction, and is a member of IES and SPIE.

USE OF DRYDEN QIII AS A MONITOR OF SURFACE PARTICLES IN A PRODUCTION WAFER FAB

DRYDEN QIII USERS' GROUP
JULY 18, 1996

Jack Livingston
Ray Bower
Gerald Keller

Motorola SPS

SYNOPSIS

The QIII Surface Scanner is useful for making rapid surface particle counts, both for in-process measurements and for cleanroom commodities.

TYPES OF TESTING

1. Wafer Box Cleanliness

   _Incoming
   _Box Cleaner Effectiveness
   _In-Process Measurements

2. Cleanroom Commodities

   _Gowns: new, laundered, used
   _Gloves: on personnel
   _Wipes

MEASUREMENT TECHNIQUE

1. Stabilization	Less than 5 minutes
2. Probe Selection	2" boxes, 3" other
3. Scan Rate	2 sec. to 6 sec.
4. Particle Size	0.3 micron for most uses
5. Dimensions	particles/in2

PARTICLE ADD-ONS DURING BOX TRANSPORT

Box	Outside top	bottom	right	Inside top	bottom
1. Tunnel	- 7.1	3.2	7.1	-180.6	-241.2
2. Tunnel	-11.0	27.7	-6.5	3.9	- 31.6
3. Manual	-13.0	19.5	36.1	22.6	0.6

Add-ons are for 10 transport cycles from fab to probe, particles/in2

Manual transport on cart, double bagged lots.
Tunnel transport via PRI automated rail system.

PARTICLE REDUCTION OF INCOMING BOXES

BOX	OUTSIDE								INSIDE						
BEFORE	TOP				BOT		SUM		TOP		BOT				SUM
	L	T	F	R	L	R			F	T	L	BK	R	BOT	
1	0.3	0.8	0.4	0.5	0.4	0.6	3		0.7	0.4	0.7	0.3	0.5	4.1	6.7
2	0.4	0.3	0.4	0.6	0.6	0.4	2.7		1.9	0.4	0.6	1.1	0.4	1.5	5.9
3	0.3	0.2	0.6	0.7	0	0.4	2.2		0.2	0.6	0.5	0.3	0.3	0.5	2.4
4	0.6	0.3	0.8	0.3	0.3	0.3	2.6		0.7	0.8	0.5	0.4	1.4	3.3	7.1
5	0.3	0.5	0.7	0.4	0.2	0.2	2.3		0.2	0.2	1.5	0.4	0.3	2.8	5.4
6	0.3	0.3	0.4	0.3	0	0.3	1.6		0.7	0.1	0.5	0	0.5	0.6	2.4
7	0.1	0.3	0.5	0.8	0.3	0.1	2.1		0.9	0	0.2	0.5	0.3	0.3	2.2
8	0.9	0.3	0.3	0.3	0.5	0.3	2.6		0.5	0.3	1.9	0.6	0.2	0.3	3.8
TOT							19.1								35.9

BOX	OUTSIDE								INSIDE						
AFTER	TOP				BOT		SUM		TOP		BOT				SUM
	L	T	F	R	L	R			F	T	L	BK	R	BOT	
1	0	0	0	0	0	0.1	0.1		0.1	0.3	0.2	0	0.1	0.1	0.8
2	0	0.2	0	0	0	0	0.2		0.1	0	0	0	0.2	0.1	0.4
3	0	0	0.1	0.1	0	0	0.2		0	0	0	0.3	0	0	0.3
4	0	0	0	0	0	0	0		0	0	0	0	0.1	0.1	0.2
5	0	0	0	0	0	0	0		0.1	0	0	0	0	0	0.1
6	0	1.3	0	0	0	0	1.3		0	0.1	0	0	0	0	0.1
7	0	0	0	0	0	0	0		0	0	0.1	0	0	0	0.1
8	0.1	0.1	0	0	0	0	0.2		0	0.2	0.1	0	0.7	0.1	1.1
TOT							2								3.1

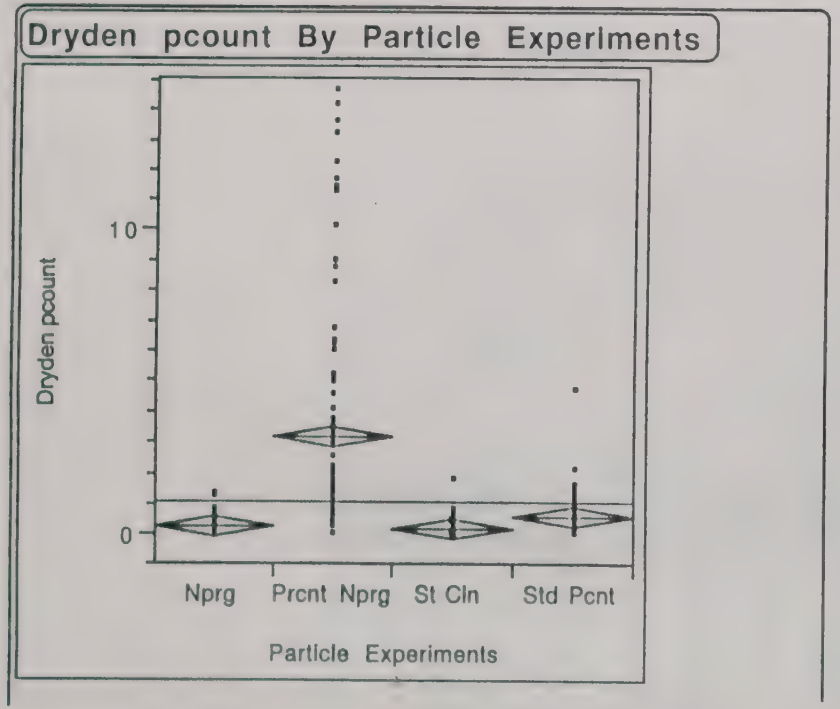
particles/in2

PARTICLE REDUCTION OF INCOMING BOXES

BOX	OUTSIDE								INSIDE						
DELTA	TOP				BOT		SUM		TOP		BOT				SUM
	L	T	F	R	L	R			F	T	L	BK	R	BOT	
1	0.3	0.8	0.4	0.5	0.4	0.5	2.9		0.6	0.1	0.5	0.3	0.4	4	5.9
2	0.4	0.1	0.4	0.6	0.6	0.4	2.5		1.8	0.4	0.6	1.1	0.2	1.4	5.5
3	0.3	0.2	0.5	0.6	0	0.4	2		0.2	0.6	0.5	0	0.3	0.5	2.1
4	0.6	0.3	0.8	0.3	0.3	0.3	2.6		0.7	0.8	0.5	0.4	1.3	3.2	6.9
5	0.3	0.5	0.7	0.4	0.2	0.2	2.3		0.1	0.2	1.5	0.4	0.3	2.8	5.3
6	0.3	-1	0.4	0.3	0	0.3	0.3		0.7	0	0.5	0	0.5	0.6	2.3
7	0.1	0.3	0.5	0.8	0.3	0.1	2.1		0.9	0	0.1	0.5	0.3	0.3	2.1
8	0.8	0.2	0.3	0.3	0.5	0.3	2.4		0.5	0.1	1.8	0.6	-0.5	0.2	2.7
TOT							17.1								32.8
		fraction remaining					0.1								0.09

particles/in2

EFFECTIVENESS OF WAFER BOX CLEANER (COMPARISON OF TWO SEMITOOL CLEAN PROGRAMS)



Oneway Anova

Summary of Fit

RSquare	0.300152
RSquare Adj	0.294627
Root Mean Square Error	1.865328
Mean of Response	1.042083
Observations (or Sum Wgts)	384

Analysis of Variance

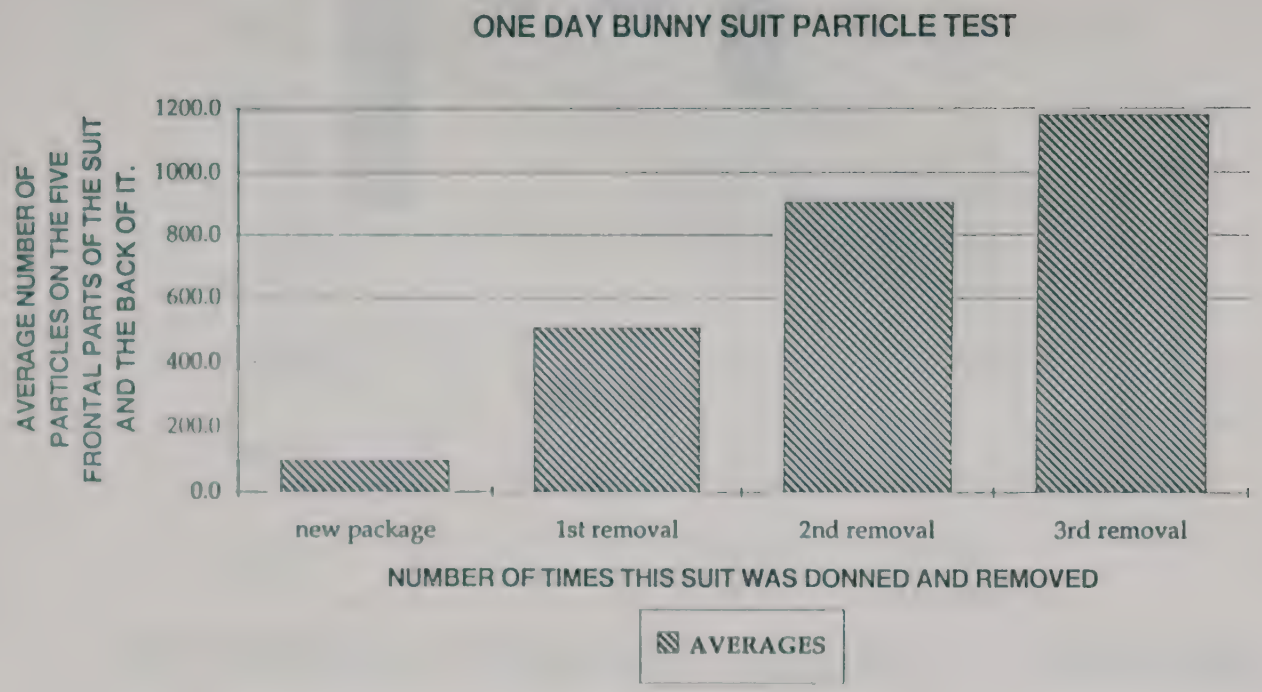
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	567.0636	189.021	54.3251
Error	380	1322.1899	3.479	Prob>F
C Total	383	1889.2535		0.0000

Means for Oneway Anova

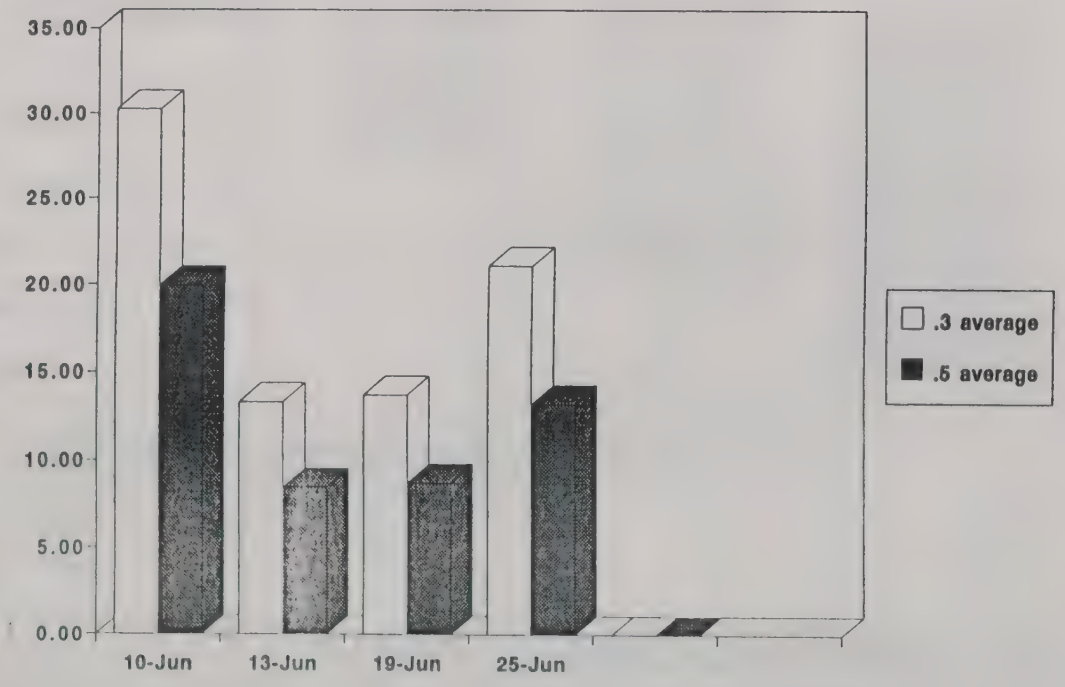
Level	Number	Mean	Std Error
Nprg	96	0.26458	0.19038
Prcnt Nprg	95	3.14379	0.19138
St Cln	97	0.18660	0.18940
Std Pcnt	96	0.60417	0.19038

Std Error uses a pooled estimate of error variance

CLEANROOM GARMENT USAGE



CLEANROOM GARMENTS, FRESHLY LAUNDERED



CLEANROOM GLOVES

Particle test W/QIII				
Glove ID		.3=	.5=	
glove A		86	56.6	top
		89.6	62.2	palm
glove B		32.8	20.3	top
		37.6	22.3	palm
glove C		83.3	61.2	top
		85.6	63.8	palm
glove D		60.2	47.3	top
		82.8	66.2	palm
glove E		93.6	71.1	top
		86.3	67.8	palm

CLEANROOM WIPERS

WIPER TEST W/ QIII						
Done on the Doc Table, first wiped down W/9% IPA						
three minute scan across the middle.						
test done on three wipers per bag; one pulled from each end and one from the middle.						
	Wiper A				Wiper B	
	0.3	0.5			0.3	0.5
#1	47	37.3		#1	23.3	19.3
#2	45.4	33.6		#2	48.9	37.3
#3	21.6	15.3		#3	50.9	38.5

FUTURE PLANS

1. Simplify Box Measurement
2. Refine Consumables Measurements
3. Determine Box Cleanliness in Fab

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	Jessie Parker
PRI	Allen Pickover

L. Lynn Armentrout

L. Lynn Armentrout is a Senior Engineer; Member, Technical Staff for Product Engineering/CFM at AMD's Fab 25, Austin, Texas. Before joining AMD, Lynn was an Environmental Senior Consultant Engineer for AMD maintaining the world class standards for Fab 25 and insuring that production engineering contamination issues would not impact wafer yields. In Addition to these duties, Lynn was Manager of Protocol for Fab 25.

Prior to his return to Austin and Fab 25, Lynn was Director of Operations for WIC, LTD.- International Operations; supervising the design teams, project managers, engineers and served as a project manager on several projects.

Lynn was a Consultant Engineer for 7 years designing systems and products for the electrical industries.

Lynn received his degrees from Arlington College in Electrical Engineering in 1970 and graduate degrees from the University of Texas at Austin in 1980, where he served as an instructor at the University of Texas in 1979 & 1980. Among the honors received are: magnum cum laude.

Lynn has three (3) design patents pending, wrote four (4) papers this year, and plans to release additional papers on Yield Management.

AMD

Cleanroom Surfaces
Building Clean and Staying Clean

Presented by;

AMD : R. Jarvis & L. Armentrout

CFM & Protocol ; Fab 25

Summary of Activities

- Cleanroom construction and qualification
- Tool deliveries & installations
- Piece Parts management
- Oops, that type of material shouldn't be in a cleanroom
- Cleanroom surfaces and wipedowns
- Conclusions & Future aspirations

Statement of Fact

- Once air filtration has begun through an ULPA ceiling, zero will be the only significant data found.
- Disturbances in the room are the only particle sources
- Particle sources are people, and surfaces; where particles land & collect
- **Conclusion: Surface detection is the next methodology for cleanroom monitoring and key to continuous protocol improvement.**

AMD
Cleanroom Construction : Build Clean

- Elimination at the source
  - The Ceiling is the most important element
  - As installed & operating, Fab 25 ceiling had >Class 100, .3um
  - The grid was cleaned to <3 P/sqin

  (Imagine the millions of particles on the acres of ceiling surface)
  - Walls, windows, columns; all installed dirty and cleaned to a single standard.
- Lesson learned:
  - 1) Proper cleaning as installed
  - **2) Room qualification Should include Surface Studies**

Tool Deliveries & Installations

- Most companies are now paying additional costs to have tools cleaned, wrapped, and delivered compatible w/Class 'X'.
- AMD, w/ the Dryden QIII Surface Particle has determined a way to insure you get your money's worth.
- The data to the right suggests we are not!
- **Lesson:Clean after delivery.**

SURFACE PARTICLE TESTING OF TOOLS
AS DELIVERED AND PLACED

(PARTICLE COUNTS AT 0.3 MICRON SIZE / INCH SQUARE)

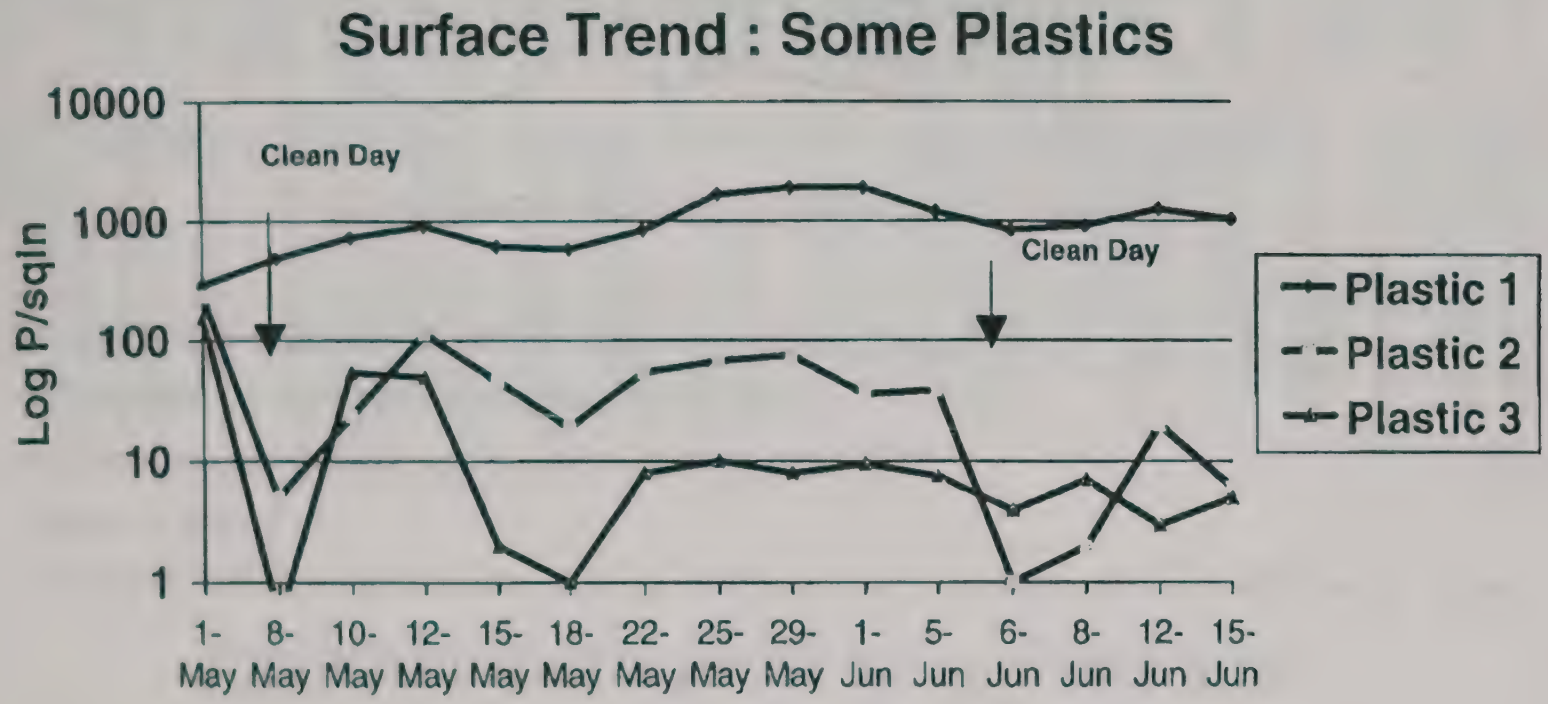
TOOL	SURFACE	BEFORE	AFTER
STEPPER	STAINLESS STEEL	729	58
	STAINLESS STEEL	706.9	36.2
	PLASTIC	1478	56
	PAINT	998.7	38.9
METROLOGY			
	STAINLESS STEEL	1449	22.7
	STAINLESS STEEL	894.6	13.4
	ANODIZE	748.7	31.6
	ANODIZE	235.1	12.5
ETCH	STAINLESS STEEL	475	58.3
	STAINLESS STEEL	723	61.4
	PLASTIC	692	23.7
	PLASTIC	831	42.8
	PLASTIC	593	34.6

Piece Parts Management

- **New tool installations most always come with boxes of parts. Issues discovered;**
  - Parts not prepared/cleaned in accordance with additional costs like the major tool
  - Parts packing not considered; bubble wrap; peanuts; foam rubber, etc..
  - Handling and storage need special considerations, especially with new installations; including order of part use during installation (parts packed with items not used on the cleanroom),
  - Special tool requirements & packing not considered critical,
- Lessons Learned
  - **Specify acceptance level and <u>method of assurance/measurement</u> with suppliers for as delivered surface particle levels.**
  - **This has extended into production maintenance practices.**

Oops, That Material Shouldn't be in a Cleanroom

- During Cleaning Days incompatible materials have been found.
- As can be seen below, not all surfaces are alike, even in the same category.
- Individual cases like this are dealt with by the tool owner/CFM/tool supplier.
- It may be enlightening to identify random particle sources, that might even degrade over time in the cleanroom environment.



Cleanroom Surfaces & Wipedowns

- Tracking many surface types; Fab 25 implemented a routine 'stop production & clean' (takes 3 hours)
- As can be seen below, all surfaces benefit from clean
- Frequency of cleaning is surface type driven
- Undesirable entities are found and dealt with individually.

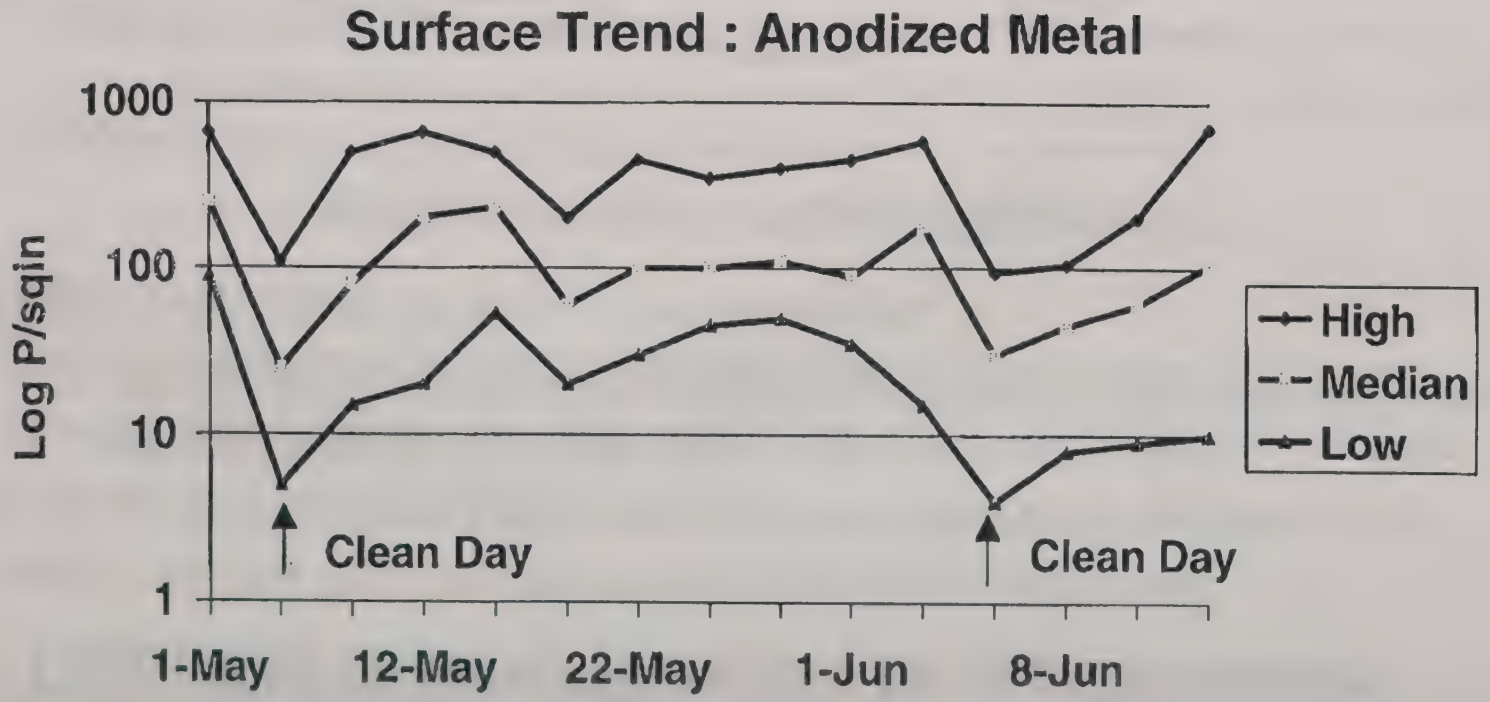


Table 1 Surfaces and Contents

	Macro Event	Microscopic Result
Direct	Contact of the cassette is during resting upon a table, robotic, or carting nest	Particle transfer is from surface to cassette, or cassette is scratched.
Smooth Plastic	A relatively cleanable surface, prone to static; horizontal installations troublesome.	Particles moved to the cassette by contact and by electrostatic, cassette is usually higher static due to grounding.
Rough Plastic	A non-cleanable surface, crevices and pores hold particles & tear wiping materials; prone to static; all installations troublesome.	Particles moved to the cassette by contact and by electrostatic, cassette is usually higher static due to grounding.
Brushed Stainless	Partially cleanable depending on coarseness, cleaning must be with the grain, or wipers are degraded	Contact can abrade and scratch the cassette.
Chrome & Polished	Mirror finishes are the most cleanable, and remain clean. Contact is non-abrasive.	With few particles to transfer, few are. Good grounding keeps shedding particles from the airflow.
Smooth Painted	A relatively cleanable surface, prone to static; horizontal installations troublesome.	Particles to the cassette by contact and electrostatic, painted surfaces are usually grounded being chemically bonded to the metal painted,
Rough Painted	A non-cleanable surface, crevices and pores hold particles & tear wiping materials; prone to static; all installations troublesome.	Particles are moved to the cassette by contact and by electrostatic, painted surfaces are usually grounded being chemically bonded to the metal painted.
Anodized	Partially cleanable depending on coarseness, cleaning is difficult with no grain, wipers are degraded	Contact can abrade the cassette. Environment can change the surface condition.
Vacinity	Non-contact of the cassette, though it is in the downstream airpath.	Particle transfer is from the random airflow model, though large occurrences, like poor operations habits or a degrading surface increases transport rates.
Smooth Plastic	A relatively cleanable surface, thought prone to static attraction; vertical installations troublesome.	Particles are moved to the cassette by dislodging particles from the surface.
Rough Plastic	A non-cleanable surface, crevices and pores hold particles and tear wiping materials; prone to static attraction; all installations troublesome.	Particles are moved to the cassette by dislodging particles from the surface. If not cleaned, surface disturbances release large particle numbers.
Brushed Stainless	Partially cleanable depending on coarseness, cleaning must be with the grain, or wipers are degraded	Airflow may dislodge some particles, though a better surface that rough painted.
Chrome & Polished	Mirror finishes are the most cleanable, and remain clean. Contact is non-abrasive.	With few particles to transfer, few are.
Smooth Painted	A relatively cleanable surface, thought prone to static attraction if the metal underneath is not well grounded.	Particles moved by airflow, so vertical installations need good grounding and frequent cleaning.
Rough Painted	A non-cleanable surface, crevices and pores hold particles and tear wiping materials; all installations troublesome.	Particles shed from this surface at all times, since they never really can get clean.
Anodized	Partially cleanable depending on coarseness, cleaning is difficult with no grain, wipers are degraded	Pores shed particles since cleaning is often not complete. Surface condition can be degraded and shed into the airflow.
Human	The most random and problematic of issues. Habits dominate particles being picked up on the gloved hand and transferred.	Particles from any surface are placed as fingerprints on the area touched. Cassettes get direct particle transfers, which go glove to cassette to glove/tool.
Smooth Plastic	A relatively cleanable surface, where fingerprints can be seen and cleaned. Troublesome due to the random nature.	Particles are moved to the cassette by contact
Rough Plastic	A non-cleanable surface, crevices and pores hold particles, fingerprints impossible to find	Particles are moved to the cassette by contact
Brushed Stainless	Partially cleanable depending on coarseness, some visibility as to surface condition for large particles.	Contact can abrade the cassette and /or gloved hand. Direct transport to cassette.
Chrome & Polished	Mirror finishes are the most cleanable, and remain clean. Contact is non-abrasive.	With few particles to transfer, few are. Non-rough surface reduces transfer of particles from gloves.
Smooth Painted	A relatively cleanable surface, fingerprints can be found easily after touched;	Particles are moved to the cassette by contact and by electrostatic, since the cassette usually has high static not well grounded on plastic.
Rough Painted	A non-cleanable surface, crevices and pores hold particles, fingerprints impossible to find	Particles are moved to the cassette by contact
Anodized	Partially cleanable depending on	Contact can abrade the cassette, and

Conclusions & Future Aspirations

- **Surface Particle monitoring has a multitude of applications:**
  - Qualifying a cleanroom by more than air alone,
  - Discovering particle transport mechanisms with surfaces as the medium,
  - Monitoring particle sources incoming into the room,
  - Improving older cleanrooms for yield/technology upgrades.
  - Get inside tools post-PM & pre-qualify PM kits,
  - Convince our suppliers that this method can be used be for shipment of tools & spares,
  - Improve the measurement technique,
  - Begin work on other sensitive fab surfaces, like cassettes.

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